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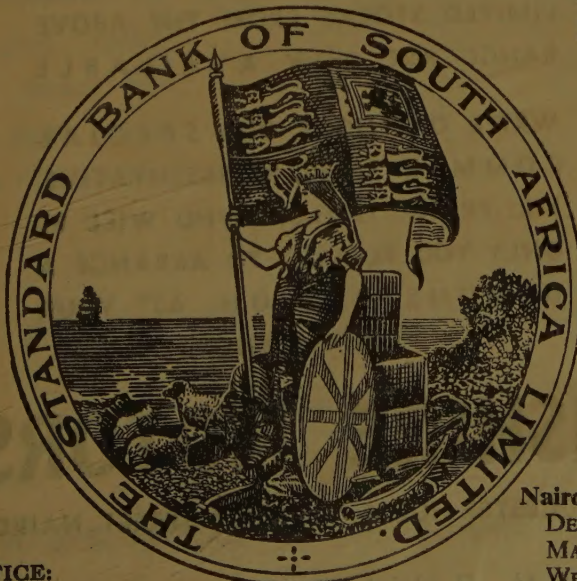
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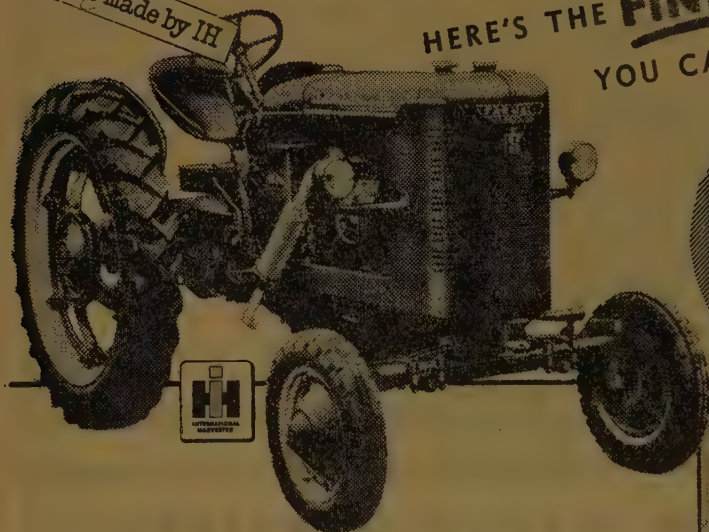
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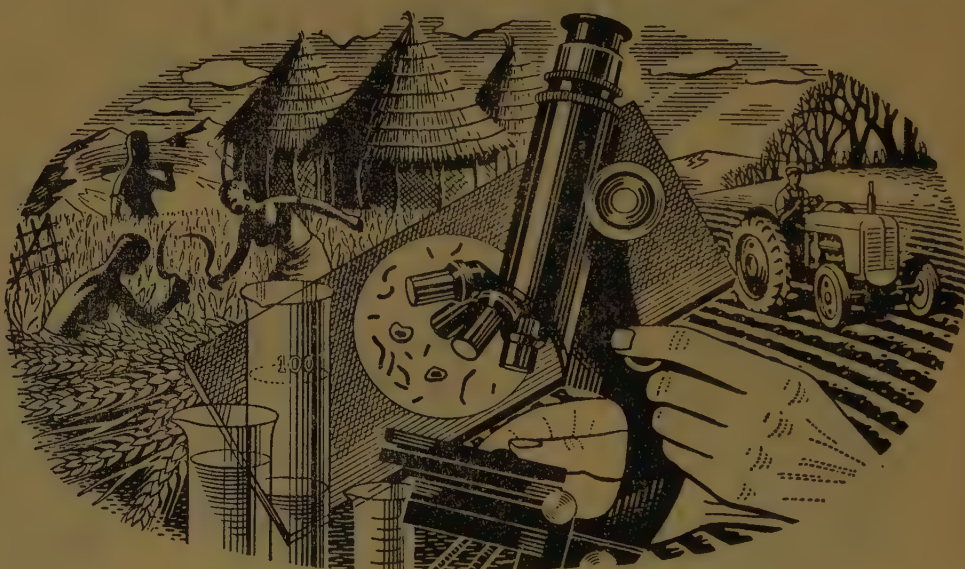
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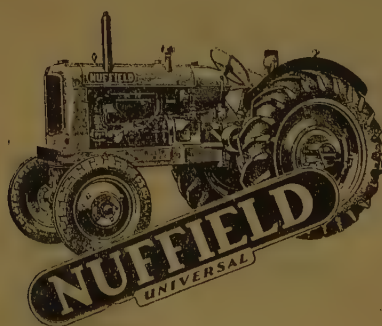
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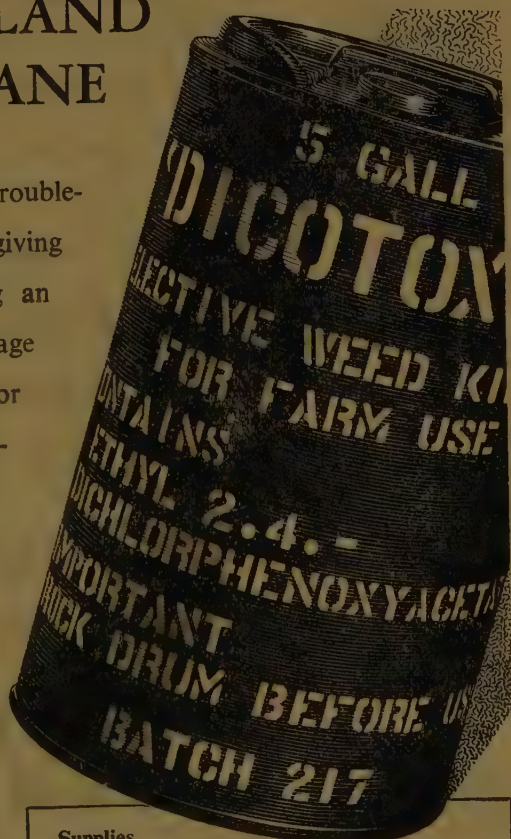
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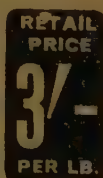
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SYSTEMIC INSECTICIDES

A fundamental advance has been made in recent years in the use of chemicals for controlling certain insect pests of plants. Hitherto, insecticides have been of two classes. One of these poisons the insect when it comes into external contact with it; the other works only when the insect eats the poison. So the contact insecticides are sprayed or dusted on the plants in the hope that particles will actually fall on the insects, or that the insects will pick up particles of it in moving over the plant. Obviously this insecticide cannot work if the insect is in such a position that spray and dust cannot reach it, or fail to reach it by accident. The stomach poisons are sprayed on to leaves in the expectation that insects eating these leaves will ingest enough poison to kill them. Insects that do not eat the leaf as a whole, but suck out its contents only through a puncture in its surface, will not be affected by a layer of the poison confined to the leaf's surface.

It will be evident from the above that the ideal insecticide for many purposes would be one that could be introduced into the plant and distributed internally throughout its tissues. Any insect then feeding on the plant would inevitably take up the poison with its food. If we could ensure that the poison became disseminated to every part of the plant, no feeding insect, wherever concealed, could avoid poisoning itself.

Research has, in fact, made important advances in the search for insecticides that can thus become disseminated within the plant. To these the name "Systemic Insecticides" has been given. Readers may well have encountered this term and may wish to know more concerning the nature of these new insecticides and the results that have been obtained from their use.

Our present knowledge on systemic insecticides has recently been summarized by Dr. W. E. Ripper, the Managing Director of a firm that has taken an important part in their development.* His paper deals with four

such insecticides, which have received enough study to allow them to be brought into limited practical use. It opens, however, with the significant mention of several new systemic insecticides as being under study; and we may expect rapid advances in the future in an insect-control technique that is still in its initial stages.

It is of some interest that one of the known systemic insecticides is sodium fluoroacetate, which occurs naturally in the South Africa plant *Dichapetalum cymosum*. The earliest to be recognized were salts of the metal selenium, following an observation that wheat grown on a naturally seleniferous soil escaped infestation by aphids. But the important recent advances have come from the laboratories of organic chemists. Following the work in Germany of Schrader (after whom the best-known systemic insecticide, *Schradan*, has been named), a number of complicated organic compounds containing phosphorus and sometimes also fluorine or sulphur have been shown to act systemically and to afford control of certain insects, particularly those that suck their food from the plant.

Systemic insecticides have been applied to the plants by soaking the seeds in them prior to sowing, by spraying on the foliage or by applying to the trunk, or by adding them to the soil around the plant roots. By any of these methods the insecticide enters the tissues of the plant and spreads through them, particularly to the young developing shoot. This last is a most important character. If a rapidly growing plant is sprayed with an external insecticide, the new shoots quickly grow away from the insecticide and expose fresh leaves that are unprotected. With a systemic insecticide these new shoots will contain the insecticide and will be protected as soon as they are formed, so long as the chemical remains toxic within the plant as a whole.

All the known systemics are extremely poisonous and must be handled with the greatest care and knowledge if accidents are not to occur. The worst danger occurs when concentrates are being diluted and contamination of the operative's hands with the concentrate can have serious results. So an interesting

* W. E. Ripper, *Systemic Insecticides*, 3rd Int. Cong. Crop Protection, Paris, 1952.

recent development is the issue of the insecticide in fixed doses enclosed in capsules; these are then buried in the soil at the plant roots, where in time the capsule disintegrates and releases the chemical into the soil. Thus the operative need not handle the concentrated chemical as such, and he escapes the most dangerous risk.

The systemic insecticides can persist in the treated plants for at least several weeks, and during this period the plants will be protected from attack by susceptible insects. Some insecticides are known to remain largely unaltered during this period; others break down in the plants to other compounds that are themselves toxic to insects. But one consequence of this persistence is that the fruits or other edible parts of the plant may contain sufficient of the chemical to make them poisonous to human beings. Each plant and chemical must be individually studied and much research is in progress to determine for each what is known as "the forbidden period"—the time that must elapse after treatment before the crop can be regarded as safe. For it is known that if sufficient time is allowed, treated plants can produce fruits that are harmless; but until there is positive evidence from research that the fruit of a treated plant will be free from poison, it must be regarded with suspicion.

All of the systemic insecticides we know to-day are highly specific in their toxicity to insects. That is, they will kill some pests but appear to have no effect on others. It seems probable that most aphids—"greenflies"—will prove to be susceptible, and the outstanding successes with systemics have mostly been with this group. Some other insects that feed by sucking the plant juices are known to be killed; these include mealy bugs, scales, thrips, plant mites and leaf-hoppers. Many species within these groups have not been tested and some that have been tested have given disappointing results. It appears also that there are some groups, even of sucking insects, that are unaffected; and no successes have been recorded with caterpillars and beetles that eat the whole leaf.

One great advantage of the systemic insecticides is that they seem to exert no ill effect on the parasites and predators which are the natural controlling agents of harmful pests. Science has long been aware of the dangers of wholesale use of powerful insecticides like

D.D.T. and B.H.C.; these can kill indiscriminately both pest and beneficial insect. Consequently it may sometimes happen that after a highly successful kill by a contact insecticide a new invasion by the pest may occur and these may multiply greatly in the resulting freedom from their natural enemies; so that the infestation may end up worse than it would have been had natural control been left to take its course. Fortunately the evidence seems to show that the parasites and predators are not affected by systemic insecticides inside the plant, so the two controlling agencies reinforce one another and are not opposed.

It happens that the types of insects that can be killed by systemic insecticides are largely those concerned in the transmission of virus diseases of plants. It was consequently hoped that these new compounds might serve to protect plants from virus diseases, which can be among the worst hazards of agriculture. In one respect, however, this hope has not been realized; there are indications that a virus-carrying insect can inoculate the virus into a treated plant when it starts to feed and complete this process of inoculation before it succumbs to the poison that it sucks from the plant. Thus work by the East African Agriculture and Forestry Research Organization has shown that a systemic insecticide cannot protect the groundnut plant from infection by aphids carrying the rosette virus. On the other hand, the fact that all the aphids on these plants were soon killed encourages the hope that further spread of the virus to other plants in the field can be checked.

As we have said, systemic insecticides are a very new scientific development. A bibliography prepared in 1952 showed few scientific papers on them that were more than three years old. Three years is a short period in the development of a fundamentally new subject. So the potential user—the farmer who hopes to see a large practical improvement in insect control from the systemic insecticides—must possess himself in patience until research has advanced further. In particular, the great dangers in handling the systemics we have cannot be too strongly emphasized; and only second to this is the risk of injuring consumers of agricultural products that have been treated. To-day the practical use of systemic insecticides is a matter for the professional only.

H.H.S.

ENCROACHMENT AND CONTROL OF SHRUBS IN RELATION TO GRASSLAND DEVELOPMENT IN AFRICA

(Substance of a paper read at the Sixth International Grassland Congress held at the Pennsylvania State College, Pennsylvania, United States of America, 17th to 23rd August, 1952)

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Encroachment of bush is more or less a world-wide problem, particularly in sparsely populated semi-arid regions. Vast areas of Tanganyika Territory are covered by dense deciduous thicket vegetation, or *Brachystegia-Isobertlinia* woodland, and one of the major problems connected with establishment of pasture and fodder crops is clearing of woody vegetation and subsequent control of regenerating bush. Furthermore, this problem is closely connected with tsetse fly incroachment and acute lack of adequate water supplies.

Economic considerations are the main factors influencing the practicability of thicket eradication. Clearing costs are high and seem to vary from five pounds to twenty pounds or more per acre. Such enormous overhead expenditure can rarely be carried by land where crop production is precarious due to variable climate, erratic rainfall and unfavourable soil conditions. Under dry-land conditions with medium to low rainfall, crops are limited to groundnuts, cotton, castor seed, tobacco and drought-resistant grain crops such as sorghum and millet. Large areas of land are marginal for cropping and although a mixed farming system seems most desirable, the bias should be strongly in favour of the development of livestock and livestock products.

In the Union of South Africa the alarming rate of encroachment of thornbush and other undesirable weeds over large areas, rendering valuable feed inaccessible to livestock, caused much concern more than 15 years ago. In many areas thornbush is so dense that its eradication is considered to be one of the first steps in reclamation work. In areas where the pasture land has been mismanaged and where fire has been completely withheld, dense, low bush is making its appearance instead of the "parkland" of the early days with a good ground cover of grass.

In carrying-out investigations on bush control a considerable number of measures were

employed, such as (a) spraying with chemicals; (b) stumping; (c) felling with and without further treatment, using ammonium sulphocyanide, sodium chlorate and paraffin; (d) air compressor machines, bulldozers, hand-operated Australian monkey winches and tractor-operated winch stump-pullers; and (e) fire combined with grazing. Stumping, although more expensive, was the most effective method of killing the bush and restoring the grass, especially on land that was treated against harvester termites.

Prickly pear was considered to be a major menace over large areas but it is now fast disappearing. Successful eradication is attributed to large-scale fellings combined with biological control with *cactoblastis* and cochineal.

In Southern Rhodesia the menace of thorn-bush encroachment with detriment to pastures, especially in the more arid parts of the colony, has been recognized for many years and extensive investigations are in progress to find most suitable methods of controlling this problem. It is considered that while sound grazing management is regarded as the first essential for the control and prevention of bush encroachment, it cannot be expected to cure areas on which dense bush already exists. Such areas must first be cleared and then by proper management kept free of bush.

In Tanganyika Territory one of the outstanding problems in connexion with suitable forms of land use is the clearing of thicket vegetation and subsequent control of regenerating bush. The major reason for carrying out large-scale bush clearing projects in Tanganyika has been to stem the advance of tsetse fly.

The following is an outline of the principal vegetation types:—

(a) Evergreen forest: High-rainfall mountainous areas.

- (b) Evergreen riverine bush and forest: Of local occurrence and confined to stream banks where adequate moisture is available.
- (c) Evergreen coastal bush: Reasonably high rainfall and favourable soil moisture conditions.
- (d) Acacia, other species open woodland: Particularly noticeable on some of the low-altitude plains in the coastal provinces.
- (e) Brachystegia-Isoberlinia deciduous woodland: By far the most extensive type covering approximately three-quarters of the Territory. Potentially it is land that seems eminently suitable for livestock and mixed farming, though on the whole it is relatively little used, due to the prevalence of tsetse fly, poor soil, lack of permanent water supplies, inadequate transport facilities and bush-clearing problems.
- (f) Deciduous thicket vegetation: Generally representative of semi-arid country and most widespread in parts of Central, Northern and Western Tanganyika. The dry season is very long, lasting for about eight months of the year. Being comparatively free of disease and tsetse fly, it is at present the most important region regarding livestock-keeping. In this region the main problem is the provision of an adequate food supply and water.

There is a tendency for vegetation communities to develop until the natural climax type is reached. This final product is directly dependent upon moisture conditions, soil and topography; and it is not always the most desirable form, especially in the semi-arid regions where it is not only useless but forms a menace to man and his domesticated animals.

It is therefore essential that the process of succession should be interrupted at a stage where the land can be put to the maximum use.

Bush Clearing and Regeneration Control

Clearing of deciduous thicket vegetation in relation to pasture improvement and fodder and crop production work has been in progress for many years on the Mpwapwa Veterinary reserve, altitude 3,500 ft. The average annual rainfall is 26 inches, nearly all of which falls between December and April; the heaviest fall is generally during March and April.

Along the hill slopes and ridges the soil is sandy to gravelly and shallow. On the fan slopes it consists of a dark red sandy loam while along the drainage lines it varies from fine silt and black loam to coarse sand. There are pockets of heavy black clay soil that cracks on drying. These seem to be remnants from old lake beds.

Large specimens of *Acacia albida* and *Ficus* species grow along the banks of sandy water-courses. On the ridges, the genera *Acacia*, *Grewia* and *Commiphora* are all represented by a considerable number of different species. *Acacia spirocarpa* and *Adansonia digitata* stand out well above the thicket-forming species and together with a number of others form very attractive trees in this semi-arid country.

Other species include *Entandrophragma bussei*, *Ostryoderris stuhlmannii*, *Cordyla africana*, *Delonix elata* and *Albizzia* species. Amongst a large number of other trees and shrubs which also occur are *Ziziphus mucronata*, *Dichrostachys glomerata*, *Courbonia edulus*, *Cassia singueana*, *Strophanthus emini*, *Acacia pinnata* and *Ehretia coerulea*.

Some shrubby plants form a dense thicket of undergrowth especially along gully banks and on stony outcrops. They include species such as *Hoslundia opposita*, *Lippia asperifolia*, *Disperma trachyphyllum*, *Acalypha ornata* and *Solanum panduraeforme*.

Combretum zeyheri, *Combretum binderianum* and other species mixed woodland generally occur along the foothills and seem to form a transition zone between deciduous thicket below and Brachystegia-Isoberlinia open woodland along the mountain slopes.

Shifting cultivation, as practised by the Africans, is carried out more or less along the following lines. The bushes and trees are cut early during the dry season from ground level to shoulder height depending upon the size of the tree and the efficiency of the implement used. The branches are closely packed over the field and fired at the end of the dry season. A field prepared in this way is cultivated for a number of years, depending upon how long it is able to continue producing crops. The land is then abandoned from cultivation; it is haphazardly grazed by stock and bush regeneration once again gets on its way. As the result of trampling by stock and erosion, the soil surface remains hard, bare and void of grass.

Grassland improvement work at Mpwapwa was commenced by felling the bush, burning the brush and then planting the bare spaces to *Cynodon plectostachyum*. This method proved fairly costly ranging between one and two pounds per acre at the time of felling, and labour wages have increased considerably since then. Regeneration soon became a major problem as all regrowth had to be slashed by hand, since stumps left on the field made it impossible to use mechanical equipment.

Some species have such large underground systems that it would be quite impossible to exhaust their root systems by continuous slashing. On plots where regenerating woody plants have been weeded and slashed consistently for about 15 years, an average of over 600 plants per acre still occur.

Mattocking is a very effective way of eradicating bush but it is expensive, costing approximately ten pounds per acre. Monkey winches have the advantage of increasing speed and more thorough removal of roots. Selective mattocking where only the thicket-forming elements are removed has also been tried. Its effects on pasture improvement are very satisfactory although the crux of the matter still remains the cost of clearing. Although hand labour is no more expensive than clearing by machine, it is becoming increasingly difficult to get labourers and their general standard of efficiency is very low.

The application of most poisons in connexion with bush control is very difficult and expensive, mainly due to labour, especially where it necessitates carting water for the preparation of solutions and emulsions. The extreme density of treating bush with over 2,000 thin-stemmed plants per acre is also a major obstacle.

Emulsions of 2-4 D Dichlorophenoxyacetic acid (Weedone) have been found to be fairly effective in checking the thickening up of bush growth. Most of the annual dicotyledonous plants such as *Astrochlaena hyoscyomoides*, *Tridax procumbens* and *Bidens pilosa* are successfully killed in this way.

Paraffin is difficult to apply and is expensive. The same applies to sodium chlorate which also has a sterilizing effect on the soil as well as a corrosive effect on pumps and clothes. We have refrained from using arsenical poisons on account of the danger to livestock.

Fire seems to be one of the major single natural factors aiding in the maintenance of

grassland or acting to convert forest and bush into grassland by the destruction of trees and shrubs. Periodic burning, preferably and necessarily combined with other treatments seems to be very effective for aiding in the control of bush regeneration.

Browsing by comparatively large numbers of goats in small plots seems to be effective in keeping down bush growth. They seem to browse most of the time and while the bushes were continuously eaten off it was very noticeable that the grass cover improved. This formed a very strong contrast to adjacent plots on which cattle were grazed. In these plots the grass cover soon disappeared, followed by a marked and rapid thickening of bush while signs of active soil erosion soon became evident. Goats and cattle on the same land in deciduous thicket vegetation, provided that grazing management is practised, seem to be a desirable combination.

From the experiments carried out at Mpwapwa it appears that goats can be kept satisfactorily on pastures obtained by clearing bushland and that they will contribute towards keeping the bush down. They should not, however, be regarded as bush-clearing agents but should rather be kept for their own value and the checking of thicket regeneration should be a secondary consideration.

Ringbarking is an effective method of killing trees and a large number of species are affected. It has, however, the disadvantage of being relatively slow and can only be effectively applied to large trees.

On small scale, and under close supervision, there does not seem to be very much difference in cost between mechanical clearing and clearing by hand, but clearing operations are more costly and more difficult during the dry season. Both methods work out at approximately ten pounds per acre, and a combination of these seems to be the ideal. At Mpwapwa, maize crops of five bags per acre are easily obtained and if calculated at one pound per bag, clearing costs are paid for in the first two years of cropping. Other and more drought-resistant crops can also be grown, for example, sorghum, castor seed, groundnuts, cowpeas and velvet beans. At Kongwa, which is situated under similar conditions, all the groundnut varieties tried on the experimental plots produced over 1,000 lb. of kernels per acre while equivalent yields were obtained from sunflower and sorghum. One variety of sorghum ("Minnesota") yielded over 2,000 lb. per acre.

Such a relatively intensive system of farming can only be adapted to comparatively limited areas suitable for arable. It encourages a better form of land usage with increased yields both from arable crops and livestock. Unfortunately it does not solve the problem of extensive areas of marginal land, where under purely ranching conditions expensive land-clearing operations are out of the question. This brings us back to the necessity of inexpensive light selective clearing to improve these areas.

Grassland Improvement

Cleared land is soon occupied by grasses, mainly annual species such as *Dactyloctenium aegyptium*, *Brachiaria serrifolia*, *Setaria pallidifusca*, *Aristida adscensionis*, *Chloris virgata* and *Chloris pichnothrix*. Some of these annual grasses provide extremely useful grazing, though their value for soil protecting and soil improving is inferior to that of perennial species. One of the most successful methods in the past has been the establishing of *Cynodon plectostachyum*, but due to the very poor viability of its seed propagation has had to be done vegetatively.

One of the main difficulties in connexion with the establishment of perennial pasture grasses has been, and still is, to obtain seed supplies of suitable grasses. A large number of species have been introduced from temperate climates in the past but these have given most disappointing results except in a few isolated areas of high altitude with high rainfall and fertile soil. *Chloris gayana* is the only indigenous species of which seeds have been produced on large scale and sold commercially, but owing to unpredictable weather conditions, the use of poor seed from unsuitable varieties, and various personal factors involved, success has by no means been universal. Some robust and drought-resistant varieties selected during recent years and which are now being developed show considerable promise. Work is also being carried out on a number of other seeding species such as *Brachiaria brizantha*, *Cenchrus ciliaris* and *Setaria sphacelata*.

Economic seed production of suitable species for use under medium- to low-rainfall conditions would make possible the establishment of grass leys in rotation with crops, and this would contribute considerably towards improving the standard of farming.

Scarcity of water is one of the main limiting factors over vast areas of Tanganyika but with

careful conservation of surplus rain-water and by developing existing supplies a large amount of fodder and crops could be produced. Very encouraging yields are being obtained from *Pennisetum purpureum*, *Setaria splendida*, *Setaria sphacelata*, and *Medicago sativa*.

Brachystegia-Isobertia Woodland

Pasture investigation work was started at Tumbi, 12 miles west of Tabora, in June, 1949. The altitude is 4,000 ft. and the average annual rainfall approximately 35 inches. The soils are sandy and are derived from underlying old granite. On the whole they are very poor, leached and deficient in minerals. The vegetation consists of typical old secondary *Brachystegia-Isobertia* woodland which is rather dense with small trees, shrubs and very numerous bushes. This thickening is due to fellings and cultivation that took place in the past and to fuel and timber cutting during recent years. In its prime state, this woodland type is much more open in nature with relatively few small shrubs and bushes underneath the large trees.

The bush-clearing work is being carried out on a basis of selective clearing, and some of the experiments include variations to determine the optimum number of trees per acre that should be left in transforming dense woodland into open park land.

The effects of clearing are most pronounced in the rapid change of herbage. Prior to clearing there is practically no grass growth apart from a few patches of *Hyparrhenia* in open glades or along drainage zones. A number of grasses soon appear and establish themselves in dense, tall-growing stands amongst the trees which are left behind. There is also a notable effect regarding the earlier appearance and longer retention of foliage on the trees in the cleared plots.

Clearing costs are rather high; on a basis of selective clearing it amounts to about three pounds per acre. Regeneration is a serious problem and although, with thorough mattocking at the outset, it will not be very formidable, there is a considerable amount of regrowth.

Cenchrus ciliaris, *Chloris gayana*, *Setaria sphacelata*, *Pennisetum purpureum* and other grasses established were found to survive the dry season and produce satisfactory growth.

Large-scale mechanical clearing has been carried out at Urambo, 60 miles west of Tabora, in typical *Brachystegia-Isobertia*

woodland, for the production of groundnuts and other crops. *Chloris gayana* is relatively easily established and promises to be a useful species for pasture and ley purposes.

Tsetse fly is a menace throughout the whole region, though the Tabora-Tumbi area has been made relatively safe as the result of drainage line clearings done recently by the East African Tsetse Research Organization.

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BOVINE INFECTIOUS PETECHIAL FEVER

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History

Infected petechial fever of cattle, widely known in Kenya as "Ondiri-disease" was first recognized and reported by Danks (1933, 1935, 1936, 1937) to whom credit for the investigational work carried out in the years prior to the Second World War must be given. It occurs mainly in pure-bred and high-grade stock on farms at high altitudes and is characterized clinically by fever, petechial hæmorrhages of the visible mucous membranes, an offensive diarrhoea and, in fatal cases, sudden collapse and death.

The disease was first examined when deaths occurred amongst milking cows on a farm near Kikuyu. It was possible to differentiate it from well-known ailments such as heartwater, hæmorrhagic septicæmia and arsenical poisoning and it became apparent that a new disease of unknown origin was present, not least because of the striking appearance of carcasses at post-mortem examination and the initial failure to effect artificial transmission.

As a result of further research, however, it was found possible to transmit the disease, using large quantities of blood drawn from reacting animals, to cattle, sheep and dogs. Horses, guinea-pigs, rabbits, rats and mice proved refractory. Since all attempts to incriminate bacterial and protozoal parasites failed consistently, the etiological agent was tentatively considered to be a virus, and the disease named "Transmissible Petechial Fever of Cattle".

Meanwhile, an increasing familiarity with the disease, together with an improved knowledge of appropriate technical procedures, resulted in successful serial transmissions through 16 animals. During this time a number of valuable observations were made regarding the pathology of the condition and the physical characters of the causal agent. It was also noted that as the number of "needle" passages increased, less and less blood was necessary to initiate infection. Thus, towards the end of the series 0.2 c.c. of blood was sufficient to

produce a typical reaction. A curious point was, however, that although this indicated an increasing adaptation of the virus to artificial transmission, there was a notable decrease in mortality in later passages.

With the onset of the Second World War, further research on this interesting disease was necessarily abandoned and it is only recently that opportunities have again arisen to effect further transmissions in cattle at Kabete with a view to resuming detailed observations on the nature of the virus. A great advance has been made, since the days when infectious petechial fever was first studied, in our knowledge of the technical procedures applicable to the study of virus diseases, and it is not impossible that the virus may eventually be adapted to, and attenuated in, laboratory small animals or fertile eggs.

The name bovine infectious petechial fever is preferred in this article since it describes the disease rather more accurately than "Transmissible Petechial Fever", "Ondiri-disease" and "Hæmorrhagic diethesis", all of which have been used, somewhat indiscriminately, from time to time.

Etiology

The causal agent is small enough to pass through special filters (Chamberland L 3) which hold back bacteria, cannot be seen by ordinary methods of microscopy, cannot be cultured on synthetic laboratory media, and only grows in the presence of living tissues. For these reasons it is justifiable to regard it as a virus.

It is a delicate organism which dies out rapidly when removed from living hosts. When stored as infective blood in a refrigerator, it becomes inactivated within ten days.

Distribution

Although the disease has been recognized in widely separated districts of Kenya, it is most commonly seen in areas of high altitude such as Kikuyu and Limuru. Some authors have stated that the incidence is higher during the rainy seasons, but many cases have been recorded during drought periods such as obtained in 1952-1953. A significant feature is the sporadic manner in which animals in a single herd are affected. A number of cases may occur, followed by long intervals during which the disease is not seen.

So far as is known infectious petechial fever is peculiar to Kenya, or at least East Africa, and has not been reported from other countries.

Animals Affected

It appears that cattle only are naturally susceptible. Cases are most commonly seen in milking cows and high-grade or pure-grade animals. Cattle with a high proportion of Zebu blood are relatively resistant. Experimentally, reactions may sometimes be induced in sheep, dogs and rabbits.

Transmission

The mode of infection is unknown, but in view of its sporadic nature, there is good reason to believe that natural transmission may be effected by a blood-sucking insect vector. Numerous transmission experiments with ticks of the *hipicephalus*, *amblyomma* and *boophilus* genera, and with insects of the *stomoxys*, *culex* and *anophiles* genera gave negative results. Nevertheless, the theory of insect transmission goes far to explain the sporadic nature of the disease and its restriction to certain areas.

A point for speculation is the fate of the virus, in endemic areas, during those periods, often of several months' duration, when the disease is absent. Since viruses generally, and the virus of infectious petechial fever in particular, have very limited powers of survival when divorced from living tissues, the existence of a reservoir host other than cattle would seem to be a prerequisite of survival. This may possibly be another domesticated animal, such as the sheep, or a wild animal or rodent.

Experimentally, the incubation period following the artificial infection of cattle with blood is usually seven to ten days. The first clinical evidence of infection is a sudden rise in temperature and this may be followed by typical symptoms and death or gradual recovery. There is a tendency for the virus to die out after the first few "needle" passages. This is often due to the difficulty of obtaining, for experimental purposes, animals with a sufficiently high proportion of exotic blood. A further point is that, although virus has been demonstrated in the bloodstream of reacting animals up to two days after the temperature has returned to normal, recent work indicates that the optimum time to draw blood for sub-inoculation is during the first temperature rise and not later in the course of the disease and this practice was not always followed in the past.

Symptoms

Early signs are a high temperature, anorexia (lack of appetite) and a sudden drop in milk

yield in lactating cows. Soon afterwards, visible clinical symptoms such as a watery discharge from the eye, petechiation (tiny blood spots) on the insides of the lips, and on the gums, nose, eyes, vulva and rectum, bleeding from the nose, swollen glands and dark tarry faeces become evident.

A very characteristic symptom not infrequently seen is a swelling and protrusion of the conjunctiva of the eye, accompanied by a gelatinous œdema. There may also be effusion of pure blood into the anterior chamber of the eye and the combined effect of these changes is to give it a "poached egg" appearance.

In acute cases the faeces become dark and tarry and emit a most offensive odour. Sometimes almost pure blood is passed from the rectum. The animal collapses and dies after two to three days.

Females in an advanced state of pregnancy, if they survive long enough, usually abort. In cows and heifers the vulva, when opened out, present a "turkey egg" appearance due to the presence of scattered petechiæ.

Post-mortem Lesions

These are very characteristic, the most striking changes being profuse localized subcutaneous, submucous and subserous hæmorrhages. Hæmorrhages may also extend deeply into groups of muscles, particularly those of the abdominal wall and diaphragm. Petechial hæmorrhages are found scattered in almost any situation.

A constant finding is extensive hæmorrhage on the inner and outer surfaces of the heart and the appearance of this organ is perhaps the most characteristic feature of infectious petechial fever. Ecchymoses ("splash" hæmorrhages) appear on the epicardial and endocardial surfaces and are usually more evident on the left side. Petechiation around the coronary grooves is commonly seen.

Hæmorrhagic ulcers and petechiæ are scattered throughout the whole length of the gastro-intestinal canal, from mouth to anus. The lower bowel may actually contain large masses of clotted blood. The mucous membrane of the abomasum (fourth stomach) is often diffusely inflamed, presenting an angry, dark red colour.

The lungs may be hyperæmic and œdematous. The lymph glands are dark and

hæmorrhagic. The spleen is usually enlarged with hæmorrhages on the external surface. The liver and kidneys appear congested. A noticeable feature is that the clotting time of the blood is considerably retarded.

Differential Diagnosis

There are two diseases with which infectious petechial fever is most commonly confused. These are arsenical poisoning and hæmorrhagic septicæmia. An immediate provisional differential diagnosis from the former can be made if it is known that the animal had a high temperature since a characteristic feature of arsenical poisoning is the absence of a febrile reaction. Confirmation can speedily be obtained by carrying out arsenic tests on suitable specimens such as abomasum and liver.

Typical of hæmorrhagic septicæmia is a yellow gelatinous œdema in the throat and neck regions. A certain diagnosis of this disease, however, can only be made by cultural and biological tests and the correct materials (citrated blood, unpreserved spleen and a long bone) should at once be obtained and despatched to the Kabete laboratories.

Other diseases with which infectious petechial fever may be confused are acute *Trypanosoma vivax* infection, heartwater and certain plant poisons. These can usually be differentiated either by the demonstration of the causal parasite concerned, or by the discovery of poisonous plants on the farm.

For the diagnosis of infectious petechial fever itself, the best material to submit is blood preserved in citrate solution, despatched on ice or maintained at the coolest possible temperature. Since the virus is extremely fragile, speed in the submission of samples is essential. In cases where the animal is found dead, unpreserved spleen, if sufficiently fresh, may contain sufficient viable virus to produce a diagnostic reaction when inoculated into experimental animals.

Should the laboratory tests for other diseases be negative, the presence of the symptoms and lesions described should be sufficient to warrant a diagnosis of infectious petechial fever although it may prove impossible to reproduce it in experimental animals.

Treatment

By the time negative reports are received from the laboratory, it will, of course, usually

be too late to treat animals from which blood has been obtained. Nevertheless, once the presence of infectious petechial fever has been established in a particular herd, some action can be taken on the next occasion an animal becomes sick with symptoms suggestive of this disease.

There is, unfortunately, only one method of treatment of proven value, and this is based on the fact that death is largely due to severe internal hæmorrhage. In an attempt to overcome this, the slow intravenous injection of 3-5 c.c. of turpentine (*Ol. terebinthinæ*) has been used on many occasions with considerable success provided the animal is in the early stages of the disease. Care must be taken that the point of the needle enters fairly into the vein so that turpentine, which is an irritant, is not deposited in the surrounding tissues.

Another method of encouraging blood coagulation is the subcutaneous injection of one ounce of gelatine made into a solution.

Immunity

A noticeable feature of infectious petechial fever is that, on farms where the disease is enzootic, cases are less frequently seen in adults born and reared on the premises. The presumption is, therefore, that an immunity is acquired during calfhood which is either permanent or constantly reinforced by contact with the infective agent. On the other hand, adult animals brought on to such farms from other areas are often highly susceptible.

Experimentally it has been shown that immunity develops some days after the completion of a reaction and a number of such animals have resisted challenge inoculations with virulent virus two years later. This indicates that immunity following recovery from natural infection is of high quality.

Prevention and Control

The nature of the virus is such that attempts to elaborate a preventive vaccine are attended by many serious technical difficulties. Nevertheless, a few trials have been made with formalized spleen vaccines, prepared and administered in a similar manner to inactivated rinderpest vaccine, and with a double inoculation method of vaccination, 5 c.c. of infective blood obtained from artificially infected sheep being given simultaneously with 20 c.c. of immune serum, with some apparent success. Thus, of six cows placed on a farm where the disease occurred regularly, three were vaccinated and three left as controls. Of the former, only one contracted a mild infection and recovered. Of the latter, all three contracted a typical form of the disease.

If the virus can eventually be adapted to small laboratory animals or fertile eggs, there will then be prospects of producing a live attenuated vaccine.

The control of infectious petechial fever by means other than vaccination is not easy. Due to the sporadic nature of the disease it is difficult to assess whether one portion of a farm is potentially more dangerous than another. Normal methods of hygiene and adequate disposal of carcasses should, of course, be practised at all times and sick animals should be promptly isolated and housed under conditions discouraging to insect life. In this connexion, since there is good reason to believe that transmission may be effected by insect vectors, the addition of a gammexane preparation to the dip and the regular treatment of animal buildings with D.D.T. or gammexane preparations may have a salutary effect.

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PROTECTION OF COB MAIZE STORED IN CRIBS

By S. Kockum, Maize and Produce Control, Kenya

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Protection of shelled maize stored in bags with insecticides has been studied in Kenya in a series of experiments by Le Pelley and Kockum (in press). Before the maize is shelled and comes into bags or silos it is usually stored by the African in storage huts and by the European farmer in rectangular cribs with wire netting walls. At this stage heavy losses are claimed by the farmer and the popular belief has been that these losses accelerate continuously as storage time is prolonged.

In the field the maize is already insect-infested, but losses are usually small, as the husk is still present and affords a great deal of protection. From past observation it has been shown that this field-infestation mainly comes from stored grain and the nearer to a store or a crib the maize grows the heavier is the infestation. Some Africans store maize with the husk on the cob and this method has been proved in experiments carried out in other countries to be good if the husk is unbroken and the stigmas (the "silk") intact, otherwise it enhances rather than deters infestation. The insect infesting ripening cobs in the field and later doing by far the most damage in the cribs, is *Calandra oryzae* L., the maize or rice weevil. *Sitotroga cerealella* Oliv., the Angoumois grain moth is also important in this respect.

During 1951 more accurate knowledge of the losses actually sustained in cribs was required in order to decide on a just compensation to farmers, as maize was held on the farms for Government under control regulations. The same year farmers using insecticides in their maize, at levels probably dangerous to the consumer, claimed excellent results. Already before 1951 many farmers had used pyrethrum powder, but with ruling prices most of them applied small amounts and the control achieved was generally poor. The time was over-ripe for a better understanding of crib storage and preservation of grain with the help of safe insecticides at this stage of grain-holding. A plan for experiment was agreed as follows:—

Two good cribs of the type used on farms were erected at the Scott Agricultural Laboratories in Nairobi (altitude 5,700 ft.). These were not placed in a maize-growing district because such experiments could not be carried out

satisfactorily far from the laboratory. The cribs were each 36 ft. by 9 ft. and 9 ft. high, covered with corrugated iron roof and with wooden floor raised from the ground on cedar poles. Each crib was divided by wire netting into compartments, six on each side, giving a total of 24 compartments each able to hold 243 cubic feet of maize. Each compartment was provided with slatted wire netting frames providing an opening for easy filling and emptying.

The experiment was set up in April, 1952, about four months after the harvesting season ended, and therefore does not give information on normal storage losses from time of harvest.

When planning this experiment it was decided that as the end compartments, eight in all, were exposed to the weather on two sides and therefore not comparable to the rest, they would be filled but not used for the actual data collected. Four treatments were used, replicated three times, leaving four compartments for untreated controls. The treatments were: (1) 0.4 per cent gamma BHC. (2.) 0.04 per cent gamma BHC. (3.) PDM (pyrethrum-diatomite mixture)*. (4.) Diatomite. The BHC dusts were prepared at our laboratory from 90 per cent gamma BHC diluted with diatomite. PDM and diatomite were supplied by the East African Diatomite Syndicate. All treatments were at the rate of 8 oz. to 9 cu. ft. of crib-space (the usual volume of cob maize calculated to give one bag of 200 lb. shelled maize) to apply the gamma BHC at the rate of one part and ten parts per million of grain.

Randomization of the treatments (by drawing from a hat) became as shown in the plan:—

1 F	2 D	3 E	4 E	5 D	6 F
7 F	8 A	9 E	10 A	11 B	12 F
13 F	14 B	15 C	16 B	17 A	18 F
19 G	20 E	21 C	22 D	23 C	24 F

- A. (8. 10. 17) 0.4% gamma BHC.
 B. (11. 14. 16) 0.04% gamma BHC.
 C. (15. 21. 23) PDM.
 D. (2. 5. 22) Diatomite.
 E. (3. 4. 9. 20) Untreated controls.
 F. (1. 6. 7. 12. 13. 18. 24) .. Filled end compartments.
 G. (19) Empty (sufficient maize was not available).

* This was applied as a proprietary product stated to contain 25 per cent pyrethrum powder and 75 per cent diatomite.

Compartment No. 20 was not used as a control when considering the final total weights as the extra exposed side may have influenced the result from this compartment.

In order to find the distribution of insect damage special wire netting cages (cylindrical about 2 ft. long and 1 ft. in diameter) were made to be placed when filled with treated (or untreated) maize at four levels (at bottom, 3 ft., 6 ft. and top) and at outside, middle and inside of each compartment, 192 cages in all.

When the cob maize arrived 200 bags were set aside to be used in the sampling cages. From each bag one cob at the time was taken and placed in 200 heaps, thus ensuring thorough mixing. A measured amount of cobs was then dusted to give the calculated treatment, and the cages were then filled with treated maize. In the compartments the maize was treated with a dust blower as these were being filled. Sample-cages were placed in the dusted maize when each level was reached. The compartments to contain 0.4 per cent gamma BHC treatment were first filled, followed by 0.04 gamma BHC, PDM, diatomite and last the untreated controls. Care was taken to prevent dust spreading to nearby compartments during application by the help of screens of cotton material.

Twenty-five samples were taken and shelled from the maize used in the cages to determine initial damage and moisture content. A further 25 samples were shelled after six weeks.

The maize on arrival was fairly heavily infested. During the first months of storage *Sitotroga* moths were swarming round the cribs in large numbers and *Hymenopterous* parasites were observed to be plentiful. As the months passed by these numbers declined.

After six months the compartments were shelled in the same order as they were filled. The complete weight of shelled maize from each compartment was recorded. Each sample-cage was shelled separately and weights recorded of cobs and grain. The maize from each of the 192 samples (after fumigation with methyl bromide to prevent insect breeding during the process of sampling) was divided into sound and damaged, number and weights being recorded as well as moisture content. Damage caused by *Calandra* and *Sitotroga* could not be separated in these examinations.

The maize shelled out as follows:—

TABLE I

Treatment	Average per compartment lb.	Cubic Feet/ Bag	% Loss Difference from Best Treatment
Untreated	3,919	12.4	22.7
Diatomite	3,960	12.3	21.9
0.04 % gamma BHC	4,375	11.1	13.7
PDM	4,722	10.3	6.8
0.4 % gamma BHC	5,069	9.6	0
(Untreated, 2 sides exposed)* ..	3,838	12.7	24.7

*(These figures are not used in the analysis of variance)

Statistical examination shows that a 643.5 lb. difference between average weights of three compartments is the least difference reliable at 5 per cent probability. No difference has been established between 0.4 per cent gamma BHC and PDM, nor between PDM and 0.04 per cent gamma BHC, but a difference is shown between 0.4 per cent gamma BHC and 0.04 per cent gamma BHC. Difference is not established between control and diatomite or 0.04 per cent gamma BHC, but it is established between these treatments and 0.4 per cent gamma BHC and PDM. High variance within the compartments was caused by interference from surrounding treatments.

The percentage of grain visibly insect-damaged from the 192 samples is shown in Table II. The figures are averages from all compartments receiving the same treatment and in same positions.

Analysis of variance was carried out using all figures and also ignoring figures from inside sample-cages.

Mr. P. Robinson, Statistician to E.A.A.F.R.O., Muguga, gave the following report:—

RESULTS IGNORING INSIDE CAGES

"The 0.4 per cent BHC gave the greatest measure of control, PDM was second, and 0.04 per cent BHC was third; diatomite was little different from the control.

On the average the lowest cages were the most affected, those just above were not so heavily affected as the bottom ones, but were more affected than the two higher ones; there was little difference between these two latter. This, however, is the overall picture—the different treatments gave different results at the different levels. With the control

TABLE II
AVERAGE PERCENTAGE OF DAMAGED GRAIN*

	UNTREATED					DIATOMITE					0.04% GAMMA BHC					PDM					0.4% GAMMA BHC				
	O	M	i	Av.	% M.c.	O	M	i	Av.	% M.c.	O	M	i	Av.	% M.c.	O	M	i	Av.	% M.c.	O	M	i	Av.	% M.c.
T ..	82	68	64	71	13.7	70	39	37	49	13.0	43	22	34	33	13.0	34	23	21	26	13.4	25	19	22	22	12.9
6ft. ..	66	47	45	53	13.4	84	49	37	57	13.2	42	25	33	33	13.0	42	23	24	30	13.1	21	22	22	22	12.9
3ft. ..	81	46	42	56	13.4	87	53	43	61	13.3	64	19	45	43	13.1	37	26	26	30	13.2	20	18	20	19	13.
B ..	83	56	64	68	13.8	83	66	62	70	13.4	61	29	61	50	13.4	34	23	21	26	13.6	27	21	24	24	13.3
Av. ..	78	54	54	62		81	52	45	59		53	24	43	40		37	24	23	28		23	20	22	22	
% M.c.	13.9	13.4	13.4		13.6	13.3	13.2	13.1		13.2	13.4	12.9	13.1		13.1	13.7	13.2	13.2		13.4	13.1	13.1	13.1		13.1

O—outside i—inside B—bottom
M—middle T—top M.c.—Average moisture content

*Calculated from counts of individual grains.

the top was more heavily infected than the cage just below, and there was then a gradual increase in the lower two cages. With diatomite there was a gradual increase from top to bottom; this is also the case, but to a lesser extent, with 0.04 per cent BHC. PDM and 0.4 per cent BHC showed similar control at all levels.

On the average, the outside of the crib is far more heavily affected than the inner cages. This is true of all treatments except 0.4 per cent BHC, which maintains a similar level of control inside and on the outside of the crib. PDM and 0.04 per cent BHC give a level of control similar to that of 0.4 per cent BHC inside, but PDM is higher than 0.4 per cent on the outside, and 0.04 per cent is higher than PDM on the outside.

There is little difference between the overall results and when the third set of cages is included, and where differences occur it will probably be due to the interaction between neighbouring compartments so that the above results are more reliable. It will be found, for example, that the innermost sets of cages for 0.04 per cent BHC are more affected than the sets in the middle of this treatment but as these sets are next to two diatomite and one control it is obvious from where the extra infection has come."

The 25 samples taken at the start of the experiment showed 10.49 per cent average damaged grain. This had risen to 18.44 per cent in a further set of 25 samples stored for six weeks, a time when it was considered most insects should have emerged and few of a further generation could have reached maturity. The treatment with 0.4 per cent gamma BHC has therefore protected the grain to a very high degree.

The distribution of damage is interesting. We are mainly concerned with an infestation of two insect species, *Sitotroga* and *Calandra*. The first is a lively, flying moth which attacks the exposed cobs and probably does not penetrate far inside. BHC is a slow-acting insecticide and will not at low concentration prevent egg-laying or kill sufficient larvæ to stop damage completely. At the higher concentration, however, it seems to do so. PDM contains pyrethrum, a quick-acting insecticide, and therefore it works better than the lower concentration of BHC on exposed sides of the crib. *Calandra*, the maize weevil, walks about all over but slips and falls down on a sufficiently smooth surface. Diato-

mite increases this slippery effect considerably. Weevils dusted with diatomite die, but this cause seems not to be of much significance in storage of maize cobs.

The moisture content of all samples was taken with a Marconi Moisture Meter and the average figures at all levels are shown in Table II. These readings given by the table of the instrument represent a moisture content slightly higher (perhaps 0.5 per cent) than the actual moisture content. Insect damage and moisture content is correlated. It is, of course, known that insects by their metabolism produce water. The outside was found in all treatments to be more moist than further in, except the 0.4 per cent gamma BHC where the moisture content was equal throughout and 0.5 per cent lower than in untreated maize.

During the first three months temperatures were slightly higher towards the centre of the cribs but during the last months the means kept approximately the same as outside temperatures in all positions. In a population study published elsewhere [1] it was found that *Calandra oryzae* increase in bags to high numbers for some months and then is controlled by a parasite, *Aplastomorpha calandrae*. Most of the damage in crib storage is probably done during the first months as indicated by the slight rise in temperature.

INSECTICIDAL DUST REMAINING AFTER SHELLING

At the time the above experiment was set up the strength of gamma BHC permitted to be used in foodstuffs in Kenya was one part per million of grain but since it was considered that much of a dust might be removed by the shelling operation the 10 parts per million strength was included. In the meantime an experiment was carried out to find the strength of BHC left in the maize after passing through a simple sheller.

Maize cobs (remaining from the lot mixed for use in sampling cages in the crib) were filled in a large box and while filling dusted with a hand dust-blower to give the strengths one part per million, ten parts per million and 100 parts per million at 9 cu. ft. to 200 lb. of clean maize. The maize did not shell out exactly on this basis so the dosage in parts per million is only an approximation (see Table I). The maize cobs were shelled on a hand-driven sheller which had no fan and where the maize only passed over an ordinary shaking grading tray before being bagged. Four samples were taken

during the shelling operation, each weighing 5 kg. These samples were analysed by Dr. J. Robinson, Chemist at the Colonial Insecticide Research at Arusha, Tanganyika [2]. The results obtained are shown in Table III.

TABLE III

Dusting Powder per 200 lb. shelled maize (estimated)		Nominal dosage of gamma BHC applied to maize cobs p.p.m.	BHC content of shelled maize average p.p.m.
Oz.	% BHC		
8	4	100	0.7
4	8	100	0.9
8	0.4	10	0.7
4	0.8	10	1.2
8	0.04	1	0.5
4	0.08	1	0.5

The highest concentrations found were 2.5 parts per million in one sample of 10 parts per million and 1.5 parts per million in one sample of 100 parts per million. The other 22 samples contained one part per million or less.

The Pest Control Committee, Kenya, after receiving interim reports of these two experiments therefore recommended that the permitted dosage of gamma BHC in cribbed maize could be raised from one part per million to 12.5 parts per million which is given by using 0.5 per cent gamma BHC in diatomite.

DISCUSSION

The general use of BHC treatment at the above rate should be able to increase the net crop of maize produced in tropical and sub-tropical countries employing crib storage by more than 20 per cent. It should also help to break the cycle of infestation from crib to field. The disadvantage common to many new varieties of high-yielding hybrid-maize of having badly covered cobs which can become heavily insect-infested in the field, would be reduced.

It has been said that a maize crib should not be wider than 8 ft. to allow the grain to dry out. A wider crib reduces the surface which is more heavily attacked by *Sitotroga cerealella* and exposed to the weather. These cribs were 9 ft. wide and nothing here supports the view of an advantage in narrower cribs.

SUMMARY

(1) A crib experiment with dust treatments of cob maize showed that a treatment with 8 oz. of 0.4 per cent gamma BHC in diatomite to 9 cu. ft. of cob maize provides an almost complete protection against insect damage over six months. A product containing pyrethrum in diatomite also gave good results. The distribution of damage and the moisture content in the crib with different treatments is shortly discussed.

(2) A second experiment planned to give information of how much BHC was retained by the grain after shelling showed that even with the very high dose of 100 parts per million only a small amount was left on the grain.

ACKNOWLEDGMENTS

The experiments were directed by the Pest Control Committee and made possible by provision of Maize and Produce Control. They were carried out in the Entomological Section of the Scott Agricultural Laboratories in Nairobi, and thanks are due to Dr. R. Le Pelley, Senior Entomologist, for his interest in the work. Acknowledgment is also due to Mr. P. Robinson, E.A.A.F.R.O., Muguga, for statistical advice and reports; to Dr. J. Robinson, Colonial Insecticide Research, Arusha, for BHC assays and to the African staff for good work counting and weighing the samples.

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KIKUYU GRASS

I—SEASONAL VARIATION IN COMPOSITION OF DEGENERATE AND PRODUCTIVE PASTURES

By H. W. Dougall, Department of Agriculture, Kenya

(Received for publication on 2nd July, 1953)

Kikuyu grass (*Pennisetum clandestinum*) is well known to most farmers in the higher altitudes of Kenya. It has been studied by Edwards [1] who has described a "Kikuyu grass zone" as occurring in a number of scattered areas situated between 6,500 and 10,000 ft. altitude where mean temperatures vary between 55° and 64° F. He considers that for the species to thrive a minimum annual rainfall of 40 in. is desirable, but states that mountain mists characteristic of these areas frequently augment actual precipitation. The kind of soil in which Kikuyu grass occurs naturally is a deep lateritic loam derived from a porous lava rock [2], of high fertility status such as is produced under undisturbed forest cover [3]. Edwards found that the legume *Trifolium johnstoni** usually is associated with Kikuyu grass when soil conditions are favourable, but decline in fertility, particularly in respect of organic matter, would lead eventually to degeneration of a mixed sward and replacement of grass and legume by less desirable species [4]. In recent years a growing amount of practical experience in certain areas, i.e., the North and South Kinangop, has indicated that a natural Kikuyu grass pasture rarely can remain productive for much longer than five or six years and indeed, in extreme cases, older pastures may fail to provide more than a few days' grazing annually. Obviously, it was necessary to seek the factors causing this marked decline in productivity, and as they became known, to examine how they might be brought under control. The farm of Mr. J. F. Lipscomb, situated at an altitude of 8,300 ft. on the exposed South Kinangop, fortunately illustrated an old, unproductive pasture and a younger, more productive one, and was selected as being entirely suitable and convenient for the kind of investigation required.

The purpose of the paper is to record essential differences between a degenerate and a productive Kikuyu grass sward, and to outline methods at present being tried in order to obtain effective regeneration of worn-out pastures.

Rainfall and Local Climate of the South Kinangop

During the period under review (July, 1952, to June, 1953), 40.62 in. of rain had fallen and was distributed monthly as follows:—

	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1952 ..	1.87	2.87	5.02	3.54	5.15	1.38
1953 ..	Jan. 0.21	Feb. 0.71	Mar. 3.08	Apr. 7.25	May 4.95	June 4.59

During the dull months of July and August, 1952, the damp, misty weather may have added slightly to the actual precipitation recorded, though this total (40.62 in.) was, in fact, 10 in. below the average for the previous 20 years.

A characteristic of this climate is the prevalence of ground frosts. These occur with varying degrees of severity principally during the months January to March, although they are not uncommon in September and early October and may occur very occasionally in June. Such frosts, when they occur, can have a profoundly deleterious effect on growing herbage.

Field Observations

It was observed that the seven-year-old degenerate, unproductive pasture supported a minimum of leafy herbage, and a dense mat of living roots and undecomposed plant residues formed an organic horizon, some three to four inches thick on the soil surface. In this circumstance lack of soil and root aeration reasonably could be inferred. The sward of the younger, 18-month-old productive pasture supported leafy herbage which could recover fairly rapidly after defoliation by a dairy herd, and it contained an abundance of indigenous clover (*Trifolium johnstoni*). A more detailed examination, however, showed that mat formation on the soil surface had begun and the clover was in fact shallow rooted, and its poorly developed rooting system, though nodulated, was tending gradually to become enveloped in a root-bound sward. It seemed reasonable to deduce that provided biotic influences continued un-

* The correct name for our *Trifolium* is *T. semipilosum* (Fres.), but as it is better known in agricultural literature under *T. johnstoni*, we retain the name here.

changed, it would be a matter of time only before the clover became excluded entirely from this sward also.

During the early months of 1952, the effect of successive frosts on the herbage of the degenerate pasture had been to damage it so badly that it was unable to recover during the remainder of that year. At the same time, re-growth herbage following early defoliation of the productive pasture also was damaged by frost, but the slower-growing legume sharing the sward remained unharmed. As the season advanced, the clover came away to dominate the pasture temporarily at the expense of the grass, but in February, 1953, a particularly heavy frost overnight reduced the legume to completely worthless herbage.

Soil Analysis

The soils supporting the degenerate pasture and the productive pasture are deeply weathered, reddish brown, somewhat heavy loams which, on analysis, gave the following results:—

TABLE I.—SOIL ANALYSIS OF DEGENERATE AND PRODUCTIVE PASTURE
(Results based on air-dry soil)

	Degenerate Pasture Soil	Productive Pasture Soil
pH	4.8	5.9
Nitrogen per cent	0.59	0.56
Organic Carbon per cent	7.41	5.91
CaO (mgm. E. per 100 gm.)	1.17	24.35
K ₂ O (mgm. E. per 100 gm.)	1.63	2.96
Total Exchangeable Bases	3.84	27.62
Ratio C : N	12.5	10.4

It is clear that the soil supporting the productive pasture is much less acid in reaction and has a markedly higher content of exchangeable calcium, this element constituting 88 per cent of its total exchangeable bases. Exchangeable potassium also is higher, although both soils contain amounts which compare favourably with an historical agricultural soil in England [5]. The ratio of C:N in both soils is very similar and does not differ greatly from the value 9.5 quoted for an old pasture soil at Rothamsted [6]. These data for the South Kinangop do not seem to lend support to Edwards' contention that degeneration in Kikuyu grass is associated largely with decline in soil organic matter. Both soils lack available phosphate as determined qualitatively by the rapid method of Bray [7].

Herbage Analysis

Herbage samples of Kikuyu grass were obtained at approximately monthly intervals from the productive pasture and from grass growing naturally without interference from grazing stock. Sampling of unproductive pasture herbage ceased at the close of 1952 for the adequate reason that lack of growth rendered sampling virtually impossible.

The data presented in Table II show seasonal variations in the percentage of crude protein, crude fibre, carbohydrate, phosphoric oxide (P₂O₅) and lime (CaO) contained in the dry matter of herbage examined.

Crude protein in herbage obtained from the productive pasture was substantially greater than in herbage from the degenerate pasture, while only in the June sample was it much less than in the natural vegetation. At the same time crude fibre almost consistently was lowest in the productive pasture. Protein was relatively high during the period mid-March to the end of June, at a time when rainfall was favourable but it was relatively low in all forms of herbage from late September to February.

The data presented for the minerals would seem to hint at the existence of an inverse relationship throughout the year between CaO and P₂O₅ in natural and in degenerate pasture herbage (Fig. 1). During the period July to December, the productive sward was grazed each month and under these conditions CaO and P₂O₅ tended to move in sympathy. Thereafter, when grazing ceased temporarily, the same pattern of inverse relationship developed. Under grazing conditions, herbage of the productive sward contained slightly less P₂O₅ than natural or degenerate pasture herbage. This is not surprising, for it will be recalled that the soils of both pastures are inadequately supplied with quickly available phosphorus and greater demands on this element were much more likely to arise in a pasture which had been defoliated regularly than in circumstances where no demands additional to those required for normal growth were being made.

Calcium in the grazed herbage usually was slightly higher than in the natural or degenerate pasture herbage but, as we have seen from Table I, the soil supporting the productive sward was very adequately supplied with this element. Calcium, however, accumulated in Kikuyu grass as the season advanced, and reached a peak in March in mature herbage or "burn". "Burn" was abundant in the Kikuyu grass growing naturally but far less conspicuous

TABLE II.—SEASONAL VARIATION IN COMPOSITION OF KIKUYU GRASS
(Results based on 100 per cent dry matter)

	CRUDE PROTEIN			CRUDE FIBRE			CARBOHYDRATE			P ₂ O ₅			CaO		
	Natural Grass	Productive Pasture	*Degenenerate Pasture	Natural Grass	Productive Pasture	*Degenenerate Pasture	Natural Grass	Productive Pasture	*Degenenerate Pasture	Natural Grass	Productive Pasture	*Degenenerate Pasture	Natural Grass	Productive Pasture	*Degenenerate Pasture
17 Jul. 1952	12.80	20.78	11.68	27.34	22.80	26.57	48.20	43.58	51.36	0.71	0.54	0.48	0.60	0.46	0.43
15 Aug. "	13.30	16.87	12.41	27.21	24.14	26.72	49.26	45.09	49.79	0.79	0.67	0.68	0.52	0.64	0.42
25 Sep. "	11.36	11.59	11.11	26.92	23.98	25.57	49.95	51.64	52.34	0.44	0.52	0.64	0.46	0.55	0.29
20 Oct. "	6.86	12.22	8.80	25.32	25.00	26.66	54.07	49.55	52.30	0.46	0.43	0.54	0.61	0.41	0.33
3 Dec. "	11.36	10.93	10.64	26.27	22.34	25.91	50.28	55.04	52.16	0.30	0.38	0.57	0.81	0.56	0.47
19 Dec. "	11.67	13.01	10.84	25.81	22.81	22.61	50.01	49.73	52.76	0.41	0.28	0.37	0.67	0.86	0.51
19 Feb. 1953	8.62	11.15	—	26.19	25.83	—	53.25	n.d.	—	0.49	0.45	—	0.64	0.88	—
25 Mar. "	14.54	19.32	—	26.60	25.75	—	46.48	42.38	—	0.83	0.65	—	0.68	0.74	—
28 Apr. "	11.10	17.90	—	26.15	22.21	—	50.32	47.13	—	0.71	0.62	—	0.55	0.59	—
25 May "	13.98	16.71	—	25.71	21.87	—	47.67	49.28	—	0.55	0.60	—	0.70	0.67	—
29 Jun. "	18.30	13.87	—	22.06	22.79	—	46.35	51.68	—	0.59	0.54	—	0.96	0.70	—

*No samples were obtained after 19th December, 1952.

in the grazed pasture. The composition of "burn" as well as the "green" material from the productive pasture and from the naturally occurring grass, were determined in February and again in March, 1953, with the following results:—

TABLE III—CaO CONTENT OF "BURN" AND OF "GREEN" MATERIAL

(Results Based on 100 per cent Dry Matter)

	PRODUCTIVE GRASS		"NATURAL" GRASS	
	Burn	Green Leafy Material	Burn	Green Leafy Material
February ..	0.72	0.58	0.84	0.64
March ..	0.78	0.74	1.08	0.68

Effect of the Legume

No attempt was made to relate the presence of clover in the productive sward to soil fertility, but it has been pointed out that the rooting system of the legume, though nodulated, was poorly developed. In the circumstances it would not be easy to assess the value of *T. johnstoni* as a "fertility builder". On the other hand there can be no doubt as to its effect on the nutritive value of a sward, as data given in Table IV illustrates. In this table the composition of Kikuyu grass alone and the grass and legume mixture are compared. The samples were obtained from the same productive pasture in October and in December, 1952. In contrast the composition of the non-legume-containing degenerate pasture during the same period is given also.

TABLE IV—EFFECT OF *T. JOHNSTONI* ON COMPOSITION OF PASTURE HERBAGE

(Results Based on 100 per cent Dry Matter)

	Productive Sward				Degenerate Sward	
	Grass Alone		Grass & Clover		Grass Alone	
	Oct.	Dec.	Oct.	Dec.	Oct.	Dec.
Ash ..	9.48	11.55	9.08	9.92	8.80	10.60
Crude Protein ..	12.22	13.01	13.91	18.62	8.80	10.84
Ether Extract ..	3.75	2.90	4.60	3.90	3.44	3.63
Crude Fibre ..	25.00	22.81	22.29	19.11	26.66	22.61
Carbohydrates ..	49.55	49.73	50.12	48.45	52.30	52.76
CaO ..	0.41	0.86	1.14	1.24	0.33	0.51
P ₂ O ₅ ..	0.43	0.28	0.49	0.38	0.54	0.37

In respect of crude protein and of minerals, especially CaO, the mixed herbage is of higher nutrient status than the grass alone and it is also less fibrous. The legume clearly has enhanced the feeding value of the pasture.

B-Carotene

"The most important of the vitamins in the nutrition of farm stock is Vitamin A or its precursor, Carotene" [8], and productive grassland herbage is the natural source of this compound. The data given in Table V show that not only was Kikuyu grass a good source of carotene but that, in general, the protein-rich pasture was also rich in carotene.

TABLE V—B-CAROTENE IN KIKUYU GRASS
(Results Based on 100 per cent Dry Matter)

Date	Kikuyu Grass	Carotene	Crude Protein
		mgm. per Kilo	
19 Dec.	From Productive Sward Grass and Legume Mixture	255	13.01
	"Burn" from Productive Sward	298	18.62
19 Feb.	"Green" from Productive Sward	72	8.22
	"Green" from Productive Sward	175	11.15
	"Burn" from "Natural" Grass	85	5.31
	"Green" from "Natural" Grass	218	8.62
25 Mar.	"Green" from Productive Sward	526	19.32
	"Green" from "Natural" Grass	318	14.54
28 Apr.	"Green" from Productive Sward	446	17.90
	"Green" from "Natural" Grass	353	11.10
25 May	"Green" from Productive Sward	378	16.71
	"Green" from "Natural" Grass	446	13.98
29 June	"Green" from Productive Sward	520	13.87
	"Green" from "Natural" Grass	504	18.30

It is observed that mature herbage, or "burn", was a very poor source of carotene and that in the natural grass, carotene gradually built up within the leaf as the season progressed. Carotene in the productive pasture declined in April and May but rose again in June in regrowth, after the pasture had been grazed.

Carbohydrate and Crude Protein

It may be anticipated that there are seasons of the year when grassland herbage can provide a plentiful supply of protein but a less adequate supply of carbohydrate, and vice versa. Data obtained during the course of this investigation and presented below in Fig II show how protein and carbohydrate were related in Kikuyu grass.

FIG. 1— P_2O_5 & CaO
per cent. of dry matter

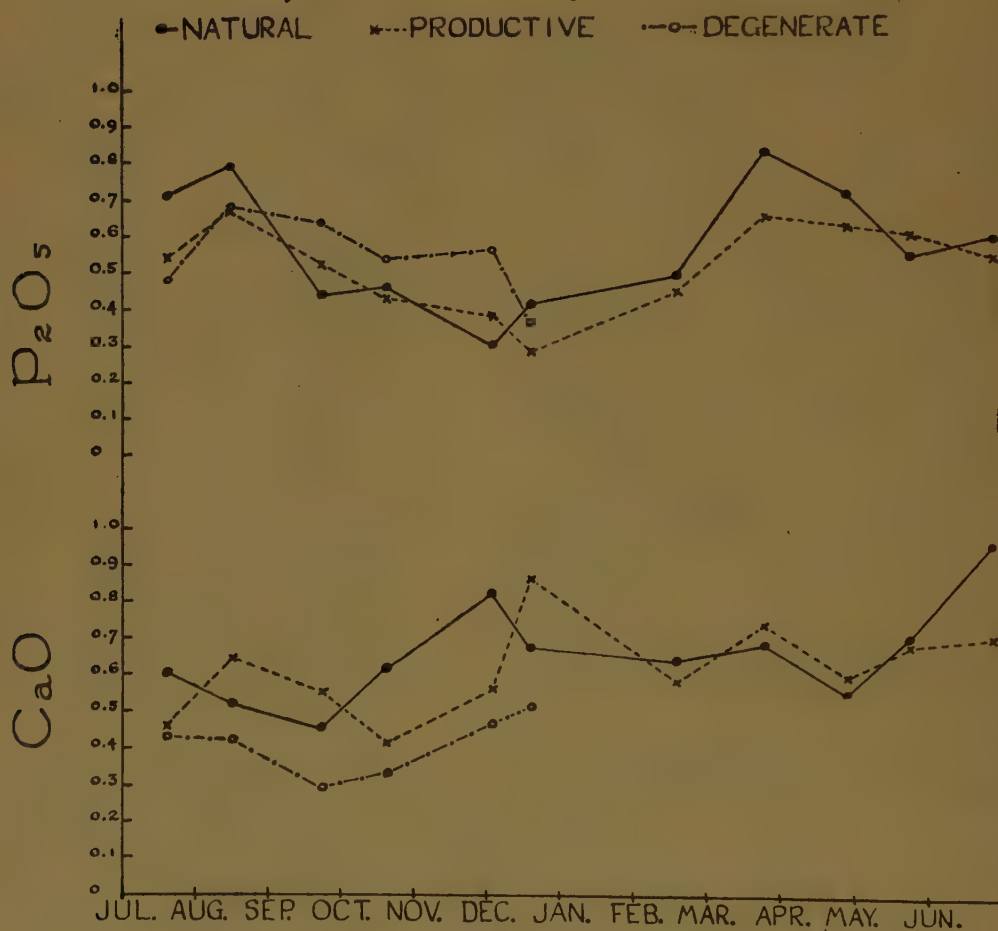
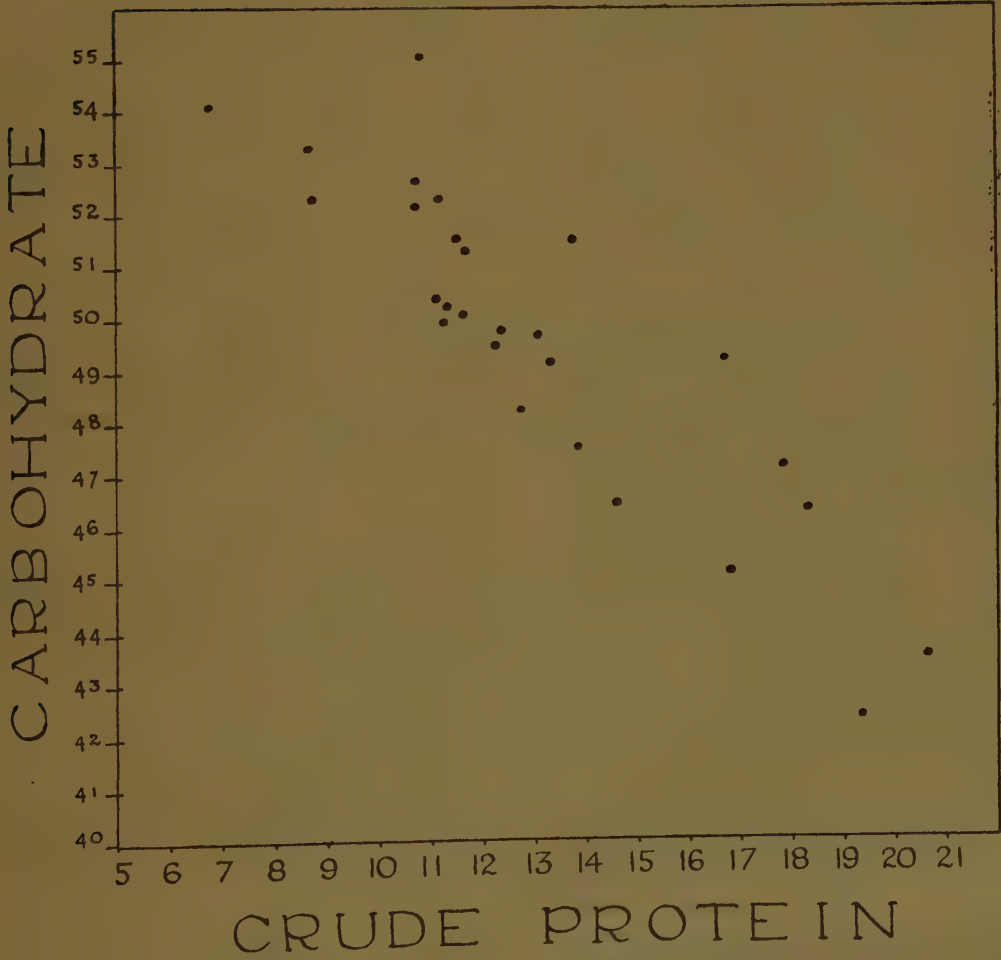


Fig.2- Carbohydrate & Crude Protein
per cent. of dry matter



Crude Fibre and Crude Protein

A relationship was found also between these two components but, without further work, cannot be considered to possess any practical merit at the present time.

Discussion

Observable characteristics of an old degenerate Kikuyu grass pasture were found to be lack of vegetative growth, the presence of "mat" composed of living roots and undecomposed plant residues and the absence or relative absence of indigenous clover. Under such conditions it is difficult to imagine how soil and root aeration can function effectively or how the indigenous clover, if present, might be expected to "fix" atmospheric nitrogen. A young, productive Kikuyu grass pasture appeared to be one which could be defoliated at regular intervals during the greater part of the year, contained little or relatively little "mat", and had the indigenous *Trifolium* clover in association.

Seasonal variation in the composition of Kikuyu grass indicated in particular a very close inverse relationship between crude protein and carbohydrate. In the South Kinangop, protein was low or relatively low during the period late September to February, when carbohydrate was relatively high. On the other hand, protein was high or relatively high in July and August, 1952, and again from mid-March to June, 1953, when carbohydrate tended relatively to be low. A practical implication suggested by the relationship is to avoid supplementing excessively either constituent during periods of the year when one or the other is most abundant.

A degenerate pasture proved an unproductive pasture from the viewpoint of herbage, protein and mineral production. Experience has shown that such pastures cannot be improved to any marked extent simply by the application of conventional fertilizers. It has been reported elsewhere [9] that with concentration of animals, deposition of manure and where night-herding paddocks have been situated on European farms, a return of *P. clandestinum* has frequently taken place. This may well be so, but such improvement is regarded in many quarters as lacking in permanency and although it is admitted that the mechanical effect of the animal hoof and the chemical effect of dung frequently will bring about a desirable change, the circumstances amount largely to a debatable system of "nutrient transfer".

How, then, may productivity be restored to degenerate pastures? In the South Kinangop, the soil of a degenerate pasture is very acid in reaction and of low plant nutrients status. It carries at its surface a useless mat of roots and plant residues, and vegetation of extremely low productivity and grazing value.

The first step, it is suggested, is a mechanical one—to break this mat either by ripping it drastically or by ploughing it under. The next step is to improve the soil nutrient status, particularly with respect to phosphorus, by applying a suitable phosphatic fertilizer. The use of an amendment—lime—to adjust soil reaction, is considered worthy of trial. Having attended to the destruction of the mat and concomitantly assisted soil and root aeration, and having raised the soil's phosphate status, a nitrogenous fertilizer is commended for the purpose of encouraging yields of leafy herbage from the regenerated pasture.

It is along these lines that work continues, using phosphorus in several forms, lime at different rates of application and nitrogen at different times throughout the year, in an endeavour to improve and maintain improved Kikuyu grass and the clover associated with it in the higher altitudes in Kenya.

ACKNOWLEDGMENTS

The writer is grateful to Mr. J. F. Lipscomb for his kind co-operation and help during the course of this work, and to Mr. G. M. Roddan, Director of Agriculture, for granting him permission to publish the results.

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MILK RECORDS OF CLASS LEADERS, 1953

By the E.A. Milk Recording Scheme, Nakuru, Kenya

CLASS 1 (UNDER 2)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	No. of Lactation	LACTATION RECORDS				
					Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
D. Lyall, N. Kinangop	Kibsworthy Matilda, <i>Eglinton Mains Baronet</i> .	Ayrshire	1-10-49	1st	1-8-51	6,986	363	4.65	329
Hafod Estates, Limuru	Gardena, <i>Kivulini Fetro</i> .	" N.P.*	14-4-48	1st	16-1-50	6,512	315	3.75	244
Mahua Farm, Limuru	Mahua Ophelia, <i>Colonies Plaats Sytische Lodewyk</i> .	Friesland	23-6-49	1st	16-5-51	4,847	285	3.94	191
H. J. Gibbs, Timau	Lugilada May Queen of LaLande, <i>Nobelman of Shanks</i> .	Guernsey	2-8-50	1st	8-7-52	4,108	254	4.45	183
Blundell Estate, Nakuru	Songhor 1st 77, <i>Fernhill Roberts Lad 10th</i> .	" N.P.	22-11-49	1st	7-3-51	6,689	300	5.28	353
Col. R. Adeame	Rainsbrook Flora, <i>Roseland Desire's Baron</i> .	Jersey	17-11-47	2nd	2-3-52	5,802	271	4.24	246
Mrs. Benn, N. Kinangop	Chege 4th	" N.P.	4-2-49	1st	25-10-49	7,966	363	5.05	399
					3-8-50	4,721	320	6.17	291

CLASS 2 (UNDER 2½)

Kivulini Ltd., Molo	Kivulini Kilbirnie 27th, <i>Killeen Peachstone</i> .	Ayrshire	13-6-49	1st	23-8-51	8,027	292	4.77	383
Lesirko Ltd., Ol' Kalou	No. 854,	" N.P.	2-2-49	1st	30-6-51	9,219	365	4.14	382
B. R. Mckenzie, Nakuru	Auchen Gilbert, <i>Oldambister Archimedes</i> .	Friesland	2-2-50	1st	6-8-52	8,647	305	3.96	342
Manera Farm, Naivasha	L.37, <i>Unknown</i> .	" N.P.	4-3-48	1st	3-4-50	8,386	365	3.88	325
Olbonata Ltd., Nakuru	Olbonata Nell A.R., <i>Peggoy's Governor of Olbonata</i> .	Guernsey	11-12-48	2nd	11-7-52	9,375	305	3.51	329
Broomhill Estates, Kiambu	Kakamega 102, <i>Ondiri Macalma</i> .	" N.P.	1-6-49	1st	1-6-51	8,070	319	4.38	353
Trefoil Jerseys, Elburgon	Favourite of Brook Farm, G.M., S.M., <i>Sybil's Junior</i> .	Jersey	4-3-48	2nd	28-7-52	9,215	305	4.18	385
D. E. Fielden, Nakuru	Kabai IV 267, <i>Ostrua Jupiter</i> .	" N.P.	6-12-49	1st	21-11-51	5,720	333	5.18	296
					26-8-50	11,333	340	5.00	567
					19-9-51	7,064	287	5.69	402
					31-1-52	8,795	365	4.82	424

*P. = Pedigree

NP. = Non-pedigree

CLASS 3 (UNDER 3)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	LACTATION RECORDS				
				No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. % B.F. (lb.)
I	2	3	4	5	6	7	8	9 10
Miss M. E. B. Atkinson, Limuru	Preston Floralin, <i>Burgower Model.</i>	Ayrshire	12-12-48	1st	25-12-52	9,299	305	4.00 372
Ciando Estates, Kiambu	Ndito 15, <i>Cianda.</i>	"	15-1-49	1st	14-9-51	9,227	340	3.36 310
B. R. Mckenzie, Nakuru	*Glenstuart N.V. Ailsa A.R., <i>Glenstuart Netherland Victory.</i>	Friesland	12-10-48	1st	7-10-52	7,323	260	3.18 233
W. Prentice, Nakuru	Gladys, <i>Glenavon Victor.</i>	"	9-6-49	1st	4-5-51	16,580	365	3.60 597
Rhodora Estates, Nakuru	Malverley's Beauty 4th, A.R., <i>Furnhill Robert's Lad 11th.</i>	Guernsey	31-10-48	1st	20-3-52	8,596	305	3.78 323
Blundell Estates, Nakuru	Keroyit 3rd, <i>Furnhill Robert's Lad 10th.</i>	"	19-12-48	1st	6-9-51	9,439	365	4.94 466
Trefoil Jerseys, Elburgon	Lankhurst Marcella 2nd, <i>Burderop Rousseau.</i>	Jersey	21-5-48	1st	30-8-51	8,933	359	4.09 365
D. E. Fielden, Nakuru	Sabia VI, 239, <i>Moyeni Designus Silver Triumph.</i>	"	24-4-49	1st	30-10-52	9,276	267	3.47 322
					7-2-51	9,447	365	5.72 540
					24-4-49	6,675	300	5.75 384

*Heifer Butterfat Record for Kenya.

CLASS 4 (UNDER 4)

Strathmore Ltd., Limuru	Auchen Blanch 3rd, <i>Strathmore Captain Kidd.</i>	Ayrshire	P	22-1-48	1st	14-6-50	6,037	308	4.02	243
Hafod Estates, Limuru	Finleclaire, <i>Mtarakwa Rex.</i>	"	N.P.	16-12-47	2nd	15-7-51	8,811	365	4.24	374
B. R. Mckenzie, Nakuru	Tusogo Lod Moline, A.R., <i>Colonies Plaats Sytsche Lodewyk.</i>	Friesland	P	3-12-47	1st	26-7-50	7,578	328	4.00	303
Mackenzie Estate, Njoro	Langok 78, <i>Menengai Zealots Prince.</i>	"	N.P.	31-12-47	2nd	16-8-51	11,826	365	3.58	423
Blundell Estate, Nakuru	Ware Lively, 13th, <i>Butterpat's Triumph of Ware.</i>	Guernsey	P	25-2-49	1st	5-9-50	10,500	300	3.35	352
Olbonata Ltd., Nakuru	Borana, 551, <i>Ruth's Hero of Whitson.</i>	"	N.P.	27-1-48	1st	8-11-51	15,991	365	3.18	509
Trefoil Jerseys, Elburgon	Favourite of Brook Farm, <i>Sybil's Junior.</i>	Jersey	P	4-3-48	2nd	11-12-50	5,223	232	3.52	184
Trefoil Jerseys, Elburgon	Maharajahs Eve, II, C.M., S.M., A.A.A., <i>Maharajah of La Commune.</i>	"	N.P.	11-6-48	1st	9-11-51	9,827	290	3.53	347
					1st	26-8-50	11,333	340	5.00	567
					2nd	19-9-51	7,064	287	5.69	402
					1st	26-9-50	5,734	253	5.04	289
					2nd	18-9-51	10,545	338	5.34	563
					3rd	29-10-52	9,031	305	5.14	464

CLASS 5 (UNDER 5)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	LACTATION RECORDS				
				No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %
1	2	3	4	5	6	7	8	9
D. Lyall, N. Kinangop	Eglinton Mains Valery, <i>Eglinton Mains Blue Ribbon.</i>	Ayrshire	23-3-47	1st	12-8-50	4,293	268	4.28
Remainder Farm, Elburgon	Farinja 1st, <i>Mtarakwa Anzac.</i>	"	20-8-46	2nd	20-9-51	12,457	260	3.65
B. R. Mckenzie, Nakuru	Mountain Fairy, A.R., <i>Karirana Vanguard.</i>	N.P.	20-8-46	3rd	15-8-52	11,807	305	3.95
				1st	17-5-50	4,928	251	4.81
				2nd	8-5-51	8,647	329	4.78
Belvedere Model Dairy Farm, Kikuyu.	Milkflow, 643, <i>Avang Umpire, 810.</i>	Friesland	11-8-45	1st	11-5-49	8,033	239	3.73
		"		2nd	20-4-50	17,700	305	3.50
				3rd	12-4-51	17,038	365	3.42
		N.P.	15-10-46	1st	29-12-49	10,956	446	3.89
				2nd	22-1-51	11,755	360	3.93
				3rd	7-8-52	10,260	305	3.60
Olbonata Ltd., Nakuru	Olbonata Sundew, A.R., <i>Ruth's Hero of Whiston</i>	Guernsey	23-8-47	1st	11-11-50	7,061	297	5.27
M. Cunningham Reid, Elmenteta.	Chebois, 2nd, <i>Kaggo Adam.</i>	"	23-11-45	2nd	17-11-51	9,386	361	5.28
Trefoil Farm, Elburgon	Lankhurst Ocarina, C.M., A.A.A., <i>Burderop Rousseau.</i>	"		1st	16-10-50	6,750	357	5.99
D. E. Fielden, Nakuru	Rubeni IV, 172, <i>Moyeni Designus Silver Triumph.</i>	Jersey	4-2-48	1st	1-3-50	5,510	340	5.13
		"		2nd	20-3-51	2,928	168	5.92
				3rd	11-3-52	10,180	302	4.86
		N.P.	22-4-47	1st	9-6-49	6,696	354	6.23
				2nd	14-5-51	11,220	350	5.36

CLASS 6 (MATURE)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	LACTATION RECORDS				
				No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %
2	3	4	5	6	7	8	9	10
Kabazi Estates Ltd., Nakuru	Harling Gaiety <i>Burgower Tablet.</i>	Ayrshire	7-1-46	2nd	7-12-49	10,626	365	4.39
				3rd	13-2-51	12,008	329	4.03
				4th	30-3-52	12,090	305	4.40
Hafod Estate, Limuru	Hilda, <i>Kivulini Petro.</i>	"	2-5-47	1st	23-12-49	9,299	280	3.97
				2nd	3-2-51	12,003	365	3.52
B. R. Mckenzie, Nakuru	Menengai Zealots Rose, A.R., <i>Karirana Ormsby Zealot.</i>	Friesland	22-4-44	3rd	8-6-52	14,042	293	3.60
				1st	18-9-49	17,876	365	3.77
				2nd	14-11-50	15,591	305	3.45
				3rd	24-10-51	11,456	314	3.51
Manera Farm, Naivasha	X.115, <i>Unknown.</i>	"	1943	1st	22-6-50	16,706	313	3.16
Blundell Estate, Nakuru	Logkinge Lady Belle, 32nd, A.R., <i>Hughenden, Lord Richmond, 4th.</i>	Guernsey	2-3-47	2nd	26-7-51	19,858	305	2.66
				1st	25-4-51	3,486	95	5.15
Ondiri Farm, Kikuyu	0-198, <i>Ondiri Millar.</i>	"	30-5-41	2nd	5-4-52	11,968	305	4.56
				1st	6-1-50	12,341	365	3.95
Trefoil Jerseys, Elburgon	Osirua Luna, O.M., G.M., S.M., <i>Capricorn of Rose.</i>	Jersey	29-9-42	2nd	22-2-50	10,085	350	5.86
				3rd	19-3-51	13,231	359	5.57
				4th	29-6-53	10,313	305	5.46
D. E. Fielden, Nakuru	*Kongoni 1st, M.M. O.M. G.M. S.M. C.M., <i>Unknown.</i>	Jersey	Mature	2nd	7-9-50	11,467	277	5.46
				3rd	25-9-51	16,112	365	5.61
				4th	30-11-52	10,508	219	5.43
Trefoil Jerseys, Elburgon	†Osirua Belinda, <i>Ostrua Furious.</i>	Jersey	29-1-46	1st	26-5-49	5,456	189	4.90
				2nd	14-5-51	16,825	365	5.14

*Butterfat Champion of Kenya, 1953.

†Butterfat Champion of Kenya, 1952.

BROWN SPOT OF MAIZE

By G. B. Wallace and Maud M. Wallace, Department of Agriculture, Tanganyika

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Brown spot is a disease of maize caused by the fungus *Physoderma maydis* Miyabe (*P. zeæ-maydis* Shaw). Its distinguishing features should be known because, apart from the importance of the disease itself, it is liable to be confused with the Rust diseases [3].

The disease was found by Mr. F. E. Luscombe, Agricultural Officer, near Moshi, Tanganyika, in early July, 1953. It is likely to have a wide distribution where conditions favour it. Brown spot was first found in India in 1910, in the U.S.A. in 1911, and in other countries later. In Africa it is known in Southern Rhodesia and West Africa. The disease affects the leaves, leaf sheaths and culms; the drying-up of these parts before the plants are mature results in reduced crops. Eddins [1] refers to losses of five to ten per cent in two of the American States. There is as yet insufficient evidence on the losses to be expected in East Africa, but Hopkins [2] records that there appears to be no material damage in Southern Rhodesia. There is no perfect control of the disease, but some precautions which can be taken are listed below. The most important contributory factors are moisture and a temperature of 23° to 30°C. All maize varieties are susceptible; the only other known host is the grass teosinte, *Euchlœna mexicana*.

Symptoms

Commencing with the lowest leaves, infection gradually spreads up the plant. Towards the base of a leaf yellowish or pale green round spots appear, and these gradually darken. On and near the midrib the spots are larger, up to half a centimetre in diameter (Fig. 1), and become dark brown or purple. They may coalesce into long stripes (Fig. 2). Away from the midrib and extending much further up the leaf large groups of very small spots appear (Fig. 2). These are rust-coloured, and translucent when held up to the light; they can be distinguished from true rusts by the absence of spore pustules breaking through the skin. The spotting sometimes occurs in successive bands across the leaf; this results from successive infections of the tissues as they have been formed at the base. The dark colour of the spots is due to the presence of numerous dark spore-organs (sporangia) in the cells below the surface (Fig. 3).

Leaf sheaths also show brown spotting, usually of the larger type, but they may be confused with spots resulting from other causes. A distinct red colour is sometimes present on the sheaths and midrib. The culm also may be affected and show numerous spots, particularly at the nodes where infection is most easily established. When culms are completely girdled they are said to be easily broken by wind.

There is a superficial resemblance between the sporangia of *Physoderma* and the uredospores of Rusts which might cause confusion in microscopic examinations. The former are, however, buried in the tissues and are not borne in pustules; they are round or oval, often flattened on one side. They are smooth and have

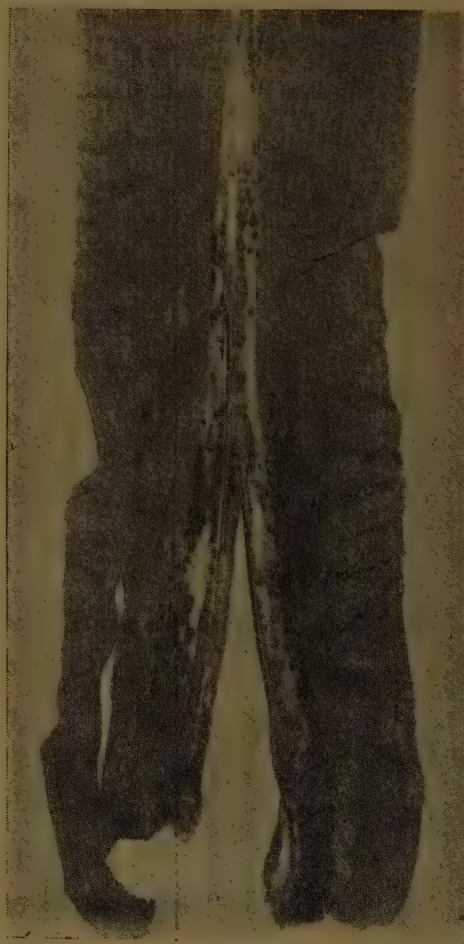


FIG. 1



FIG. 2

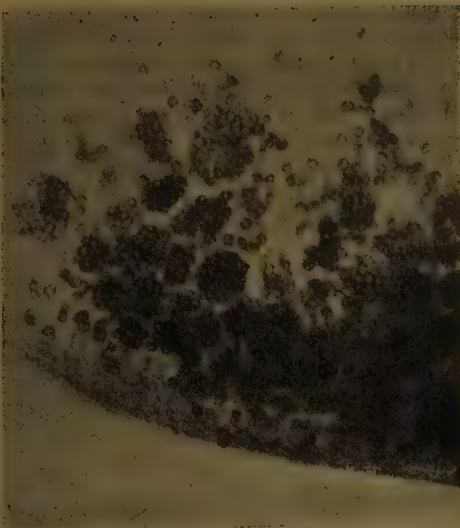


FIG. 3

no surface spines as do the Rust uredospores. They are released when the plant tissues disintegrate. In the presence of moisture, and at a moderately high temperature, they open to liberate zoospores which swim about for a period. If these later come in contact with susceptible maize parts, they germinate and cause infection.

Predisposing Causes

As already stated, the development of *Physoderma* is largely dependent upon the presence of moisture and a high temperature—23° to 30°C. (73° to 86°F.) according to Tisdale [4]. The disease is therefore more likely to occur in the lower maize-growing belt than in the higher. According to Eddins [1] the spore-bearing organs can persist for two years in maize refuse and in the soil.

Spread of the fungus is mostly by wind; flowing water, as in irrigation furrows, could also carry infection. Infected maize used for silage or compost could be a danger.

Control

While there is no complete control for this disease, there are a few precautions that can be taken to reduce infection. Infective material would ideally be best disposed of by burning and this would also destroy other organisms such as the ear-rot fungi. Should this be considered too wasteful, the only effective alternative would be complete ploughing-in. Stacking of maize trash is a dangerous practice, as various fungus parasites may not only persist, but multiply in the stacks: drying out of scattered trash would be preferable to stacking if ploughing-in is not possible. Maize for silage or fodder should be cut low.

Compost made from infected maize trash should not be applied to land which has not previously borne an infected crop.

Rotation of maize with other crops will reduce infection, the maize being grown as far as possible from land which is known to be infected. Windbreaks which encourage the retention of moisture should be avoided.

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AGE-CHANGES IN THE TEETH OF ZEBU CATTLE

By S. B. Kikule, Assistant Agricultural Officer, Serere, Uganda

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When life-history records of herds of cattle are not being kept, it would be of some assistance to stockowners and others to be able to estimate the age of cattle from the development of their teeth. Such a method of estimation would be of great practical value for various reasons. Improvement of beef production by selective breeding would be possible if the farmer were able to select the early-maturing type by observing the state of teeth development while the animal was growing. The sale for export of immature animals could be easily controlled as their ages could be gauged nearly enough for practical purposes by their teeth. Farmers wishing to purchase good foundation stock for breeding purposes would have a guide to the age. It would also enable workers in the field to estimate the age of dead animals when carrying out post-mortem examinations. It is well known that the variation in the number and condition of the teeth in European breeds of cattle (*Bos taurus*) can be used to some extent to determine age. The Animal Health Research Centre at Entebbe have made similar observations on Zebu and Ankole cattle (*Bos indicus*) and compared their results with those from European breeds. The intention of this paper is, therefore, to record observations on the Serere Zebu Herd, and to compare this data with that of European breeds and the Entebbe mixed Zebu and Ankole Herds.

Procedure

There are approximately 310 head of cattle on Serere Experiment Station. About 120 beasts were excluded, the largest number of these being young stock under the age of one year. Again, all those animals which were not born on the Farm were excluded as their correct ages were not known, and all those animals which are managed on the Free Range system—see Williams, E., and Bunge, V. A. [1]. The data were obtained from the remaining 187 head of cattle. The ages of individual beasts in this group varied from one to ten years and it consisted of approximately equal numbers of male and female stock.

All the animals examined possess brand numbers and names and a complete life history of each is known. Teeth were recorded as follows:—

Dentition Group

- I—Four pairs of temporary incisors (between eruption and full wear).

II—First pair permanent incisors (between eruption and full wear).

III—Second pair permanent incisors (between eruption and full wear).

IV—Third pair permanent incisors (between eruption and full wear).

V—Fourth pair permanent incisors (between eruption and full wear).

VI—Mouth in full wear.

No records were taken of the eruption of molar teeth. It will be understood that mouths of intermediate type are to be expected and were in fact found. Seven such cases were recorded and excluded from Table I. (Page 87.)

Results

The results from these observations are tabulated in Table I and eruptions are illustrated in Diagram I.

Time of eruption was assumed to be the earliest date at which the incisors were observed. Thus, for example, in dentition group II, the age variation is between 27 and 32 months, but I have assumed the eruption age to be at 27 months. Based on this system, the results in Table II give the eruption dates of the Serere herd of Zebu cattle compared with European stock and the herds at Entebbe. In unpublished notes showing the teeth eruption in the Entebbe cattle (mixed herd of Zebu and Ankole types) it was found that European cattle erupt their teeth earlier by about one year. Our observations here show that the Bukedi Zebu cattle under Serere conditions and systems of management erupt their teeth some two to eight months later than European cattle managed under European standards of farming.

TABLE II—TABLE OF COMPARATIVE PERMANENT INCISOR TEETH ERUPTIONS

(In Months)

Period of Eruption	European Standard	Entebbe Standard (Mixed Zebu and Ankole)	Serere Standard (Bukedi Zebu)
1st pair permanent incisors	22	31	27
2nd	30	36	32
3rd	36	44	40
4th	39	54	47

Miller and Robertson [2] state that "The eruption of the permanent teeth is subject to very considerable variations, and that the eruption of teeth is influenced by domestication, methods of management, and the nature of food, and what applies to the more highly specialized improved breeds does not apply to commonly bred cattle and also that what applies to these latter does not hold good for ranch cattle." I should mention here that weights at birth as well as monthly average liveweight gains of our Free Range calves have, in the majority of cases, been very much higher than those of other calves reared under different systems at Serere. For instance, one of the Free Range calves (Dam No. 126 Inyou) attained the exceptional (for Serere) liveweight of 409 lb. at the age of nine months but it is still too early to say anything about his teeth eruptions.

It is also stated by the same authors that "artificial methods of management, forced feeding upon concentrated foodstuffs and the selection of early-maturing breeding types have combined to produce earlier and earlier eruption of the teeth, so that very considerable variation now exists between breeds of stock which are managed under an intensive system and those that are kept under more natural conditions". In this connexion, it is interesting to note that one bull calf, No. L 145 Watson (born 12th November, 1950), has grown very rapidly and reached the weight of 425 lb. at the age of 15 months, the average for bull calves of the same age at Serere being 235 lb.

Contrary to Miller and Robertson's findings as explained above it should be noted that at the time of writing (31st December, 1952) this particular bull had not erupted his first pair of permanent incisors at the age of 25 months (his liveweight being 601 lb.). This is, of course, not conclusive but it remains to be seen whether this young bull will go through his periods of eruption in advance of the other animals examined.

Broadly speaking, it may be said that development in cattle is much delayed and stunted under the Teso African system of husbandry where standards of management are much lower than those prevailing at Serere Experiment Farm.

ACKNOWLEDGMENTS

I wish to express my grateful thanks to Mr. J. M. Watson, Officer in Charge, Serere, for drawing my attention to this problem, and to Dr. J. I. Taylor, Animal Health Research Centre, Entebbe, and Mr. D. J. Parsons, Agricultural Officer, for much helpful criticism and guidance. I am also indebted to Messrs. J. MacDonald, J. Sempala and J. Kairumba of the Veterinary Department, for useful information on Bukedi cattle.

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- [2] Miller, W. C., and Robertson, E. D. S. (1947). *Practical Animal Husbandry*, Oliver & Boyd, Edinburgh, pp. 346, 370-376.

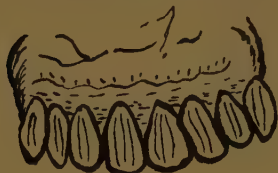
TABLE I—A DETAILED DESCRIPTION OF DENTITION GROUPS

Dentition Group	No. of Beasts Examined	No. of each Sex represented	Average Weight for each group	Range of lightest to heaviest animals in lb.	Age Variations in months
I	37	20 Male .. 17 Female	290 lb.	185-425	12-25
II	22	14 Male .. 8 Female	440 lb.	330-380	27-32
III	21	15 Male .. 6 Female	538 lb.	400-700	32-40
IV	25	19 Male .. 6 Female	603 lb.	480-800	40-54
V	32	12 Male .. 20 Female	687 lb.	510-860	47-72
VI	43	18 Male .. 25 Female	720 lb.	590-1,000	63-120

DIAGRAMS OF TEETH AT VARIOUS AGES

No. I

FOUR TEMPORARY INCISORS



No. II

PERMANENT INCISORS—ONE PAIR
(CENTRAL UP)

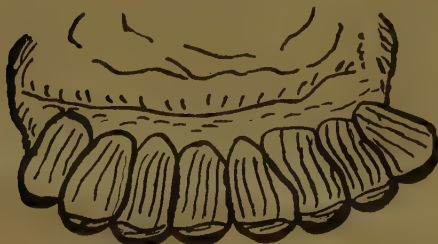
No. III

PERMANENT INCISORS—TWO PAIRS
(MIDDLE UP)

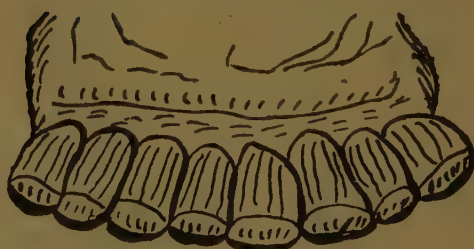
No. IV

PERMANENT INCISORS—THREE PAIRS
(LATERAL UP)

No. V

PERMANENT INCISORS—FOUR PAIRS
(CORNER UP)

No. VI

*PERMANENT INCISORS—FOUR PAIRS
(FULL MOUTH IN WEAR)

* This varies according to the type of pasture on which the animals graze.

TREE-PLANTING IN TANGANYIKA

II. Species for the Highlands

By M. S. Parry, Forest Department, Tanganyika Territory

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In the previous article three major climatic zones were distinguished for the purposes of afforestation. The present article deals with species commonly used or recommended for trial in the Highlands or Temperate Zone, which includes all mountain areas, Bukoba District and the Southern Highlands plateau.

ACACIA SPECIES

Acacia melanoxylon: Australian Blackwood.—A handsome fast-growing tree with an erect habit and a dense symmetrical crown of narrow pyramidal form. Suitable for planting as windbreaks or live firelines in areas having not less than 40 in. of rainfall. It yields straight, durable, large-sized poles or, if grown on a longer rotation of 20-30 years will exceed a height of 100 ft. and produce a very hard timber of dark colour and medium dimensions. The timber has been used in Australia and South Africa for furniture.

Like Black Wattle it can be established by direct sowing, but is more exacting in its soil requirements and is usually more difficult to raise by this means. There are from 20,000 to 40,000 seeds to a pound. It is best planted from "stumps" raised by broadcast sowing about ten months before the planting season. It is one of the very few species that are completely resistant to termites even in the seedling stage.

It coppices readily when clear-felled and also produces an abundance of root suckers, which can be a nuisance in a garden or in farmland.

The rate of growth is usually rather less than that of Black Wattle in the early stages, averaging 6 ft. a year, but it reaches larger dimensions and will outstrip the wattle after a few years. On a pole-crop rotation (5-12 years) the yield per acre would be comparable with that of wattle and the produce would be of rather better quality. It yields tanning bark but is not planted commercially for this purpose.

Blackwood is unfortunately very susceptible to infestation by species of *Loranthus* (parasitic plants of the Mistletoe type) and in many places never matures to a large tree for this reason.

Acacia mollissima: Black Wattle.—One of the most popular species for fuel and pole plantations, but does not attain timber dimensions. Suitable for most soil types, and, in favourable situations, is exceptionally fast growing, reaching a height of 40-50 ft. in five or six years. It will survive with a rainfall as low as 30 in., but is not recommended for areas with less than 40 in.

Seed averages about 30,000 per lb. and is readily obtainable in quantity. The seed needs to be plunged into boiling water and left to soak overnight before sowing. Plantations are easily established by direct sowing in spots or lines, preferably in land being used simultaneously for crops, as the seedlings are very liable to check badly and become spindly if not clean-weeded. The usual sowing rate is about 1 or 2 lb. seeds per acre.

The species is usually grown on a rotation of about eight years. It will not coppice very freely, but regeneration is easily effected by clear-felling, and burning the slash shortly before the onset of the rains. If a good burn is obtained, seed lying dormant on the ground germinates readily, and produces an abundance of young seedlings, which should require only one weeding operation and subsequent thinning to become established. In very wet areas, some difficulty may be experienced in obtaining an adequate burn, and replanting may be necessary. The use of fire to regenerate wattle has been condemned by South African silviculturists, because it may cause loss of nutrients, slows up decomposition of litter, and involves exposing the soil to the risk of erosion at fairly frequent intervals. It can also stimulate regeneration on such a prodigious scale that thinning becomes very laborious. In East Africa, however, with small-scale wood-lots, these difficulties are not usually serious. The dense leaf litter and mass of roots are well able to hold the soil for the few months following a burn, and excessive regeneration is often useful in providing an intermediate yield of withies. Erosion under wattle is usually caused either by careless logging or by cattle grazing through under-thinned plantations.

Thinning is a very necessary operation after regeneration by fire. Unless there is a big demand for withies it should be done by pulling out surplus seedlings while they are still small. If neglected, the plantation will produce only a mass of weak straggly "beansticks".

Black Wattle is not resistant to termite attack even when growing rapidly. In some areas such as Kasulu its use is limited for this reason.

In addition to providing a very good fuel and useful non-durable poles, the wattle yields a valuable commercial product in the form of tannin bark, which at present prices is sufficient in itself to repay costs of planting. An average yield from a good 8-year-old plantation would be about 50 tons fuel, and six tons of dry bark per acre.

For a detailed account of the silviculture of wattle with particular reference to bark production, the reader is referred to Bulletin No. 31, 1947, of the S. African Dept. of Forestry ("The Silviculture of Black Wattle", by S. P. Sherry).

ARAUCARIA SPECIES

Rather surprisingly these interesting trees have not been planted extensively in Tanganyika, and the genus is represented only by a few ornamental trees, notably at Amani where five species are growing well: viz. *A. brasiliana*, *A. bidwillii*, *A. cookii*, *A. cunninghamii* and *A. excelsa*.

The largest and least bizarre-looking is *A. excelsa* the Norfolk Island Pine. Three trees of this species at Amani about 45 years old have an average height of 120 ft., and a mean girth of 8 ft. 3 in. The trees have a perfectly symmetrical shape and attractive foliage.

The timber of most species is a typical useful softwood, resembling deal. The species are not drought-resistant, but should grow well in moist temperate situations and medium elevations (e.g. Lushoto, Arusha). They are very fast growing. Seed is not easy to obtain locally and soon loses viability.

All species form mycorrhizae and may need inoculation when introduced to new areas. One tree at Amani has grown only 3 ft. in 15 years, probably owing to mycorrhiza deficiency. Fungi from farmyard manure or soil from pine plantations would probably serve the purpose.

A. cunninghamii, the Hoop Pine, is one of the better species for timber production and is planted extensively in its native Queensland.

The few trees at Amani are seeding fairly well and the tree is now being raised for trial elsewhere. It does not transplant easily, and the Queensland Forest Service has developed an elaborate technique for raising the trees in metal tubes 8 in. long. The method has been described in an unpublished technical note of the Kenya Forest Department.

A. cookii is also producing a little seed at Amani; the other species produce negligible amounts. *A. cunninghamii* and *A. cookii* both have a rather attractive shape and foliage resembling the Norfolk Island Pine but *A. bidwillii* and *A. brasiliana* have the hideous appearance characteristic of the Monkey Puzzle of English gardens.

Callitris spp.: "Cypress Pines".—*C. robusta* and *C. calcarata* have been tried in various places including S. Kilimanjaro, where they grow well but no better than pines or cypress. They are reputed to be very drought-resistant and should be useful for the afforestation of dry areas in the mountains. The timber is more durable than that of most conifers.

Calodendrum capense: Cape Chestnut.—An indigenous tree of the dry temperate forests, having large beautiful lilac-blue flowers. The timber is useful, tough and easily worked. It has not been tried in plantations but is commonly used as an ornamental. Seed ripens in June, and averages about 500 to the lb. For ornamental use it should be raised in pots.

Cinnamomum camphora: Japanese Camphor.—This is the true camphor (as distinct from East African Camphor-wood which is *Ocotea usambarensis*). A pole or timber species which shows considerable promise in plantations at Amani, Lushoto and South Kilimanjaro. Requires a fairly high rainfall. The whole plant yields commercial camphor and a small distillation plant was operated at Lushoto during the war, but no facilities for extraction now exist in East Africa as the quantity available is negligible. The timber is the well-known "camphor" wood from which carved chests are made in the Far East.

It is most easily planted from "stumps". There are about 3,000 to 5,000 seeds to a lb. Seed ripens in April and should be cleaned to remove the outer pulp before being dried. It should be sown as soon as collected, transplanted to a spacing of 8 in. x 8 in. when 2 in. high and the transplants lifted and "stumped" for planting out in the long rains of March/April. Alternatively, seed can be kept and sown about September and the seedlings potted.

No yield data are available, but plantations have averaged about 4 ft. height growth per annum for the first ten years and should be suitable for poles if worked on a ten-year rotation. The tree coppices vigorously when clear-felled. Mature trees felled at Lushoto have also produced masses of root-suckers.

Poles obtained from young coppice shoots are usually very straight, but trees in mature plantations at Amani are badly shaped with spreading branchy crowns. It does not easily kill out weed growth unless grown very dense, and is very liable to be smothered by climbers.

The tree has an attractive shiny green foliage and is often used in Usambara as an ornamental tree, or for hedges. It withstands a surprising amount of shade and is growing well as an under-storey tree under mature Pencil Cedar in Lushoto.

In Lushoto a shoot-borer has been observed to damage the trees, but has not yet become a serious pest.

Cryptomeria japonica: Japanese Cedar.—A valuable exotic which has not been planted extensively as it is rather slow growing and not easy to establish. The timber is light but durable and of very good quality, but of rather small dimensions. The tree has an excellent form with a very straight bole, and few side branches. It has therefore much to recommend it for providing first quality poles in large sizes. German plantations in West Uluguru planted about 1912 had attained in 1946 a height of 74 ft., and a standing volume of 5,000 cu. ft. per acre, of wood over 8 in. diameter, plus 4,600 cu. ft. of small-wood. Timber removed in thinnings had amounted to about 2,000 cu. ft.

Seed is not easy to obtain and does not germinate freely. It can best be established by means of vigorous potted transplants about 12 in. high. It requires about 12 months in the nursery. It needs a moist climate (at least 45 in.) and is rather exacting in its soil requirements, preferring a deep moist loam.

This tree has possibilities for the higher rainfall areas in the mountains, in places considered too wet for the healthy growth of cypresses.

CUPRESSUS SPECIES: CYPRESSES

Cupressus lusitanica: Mexican Cypress.—The most widely planted conifer in East Africa, having been planted very extensively in Kenya to replace the indigenous temperate rain-forest. Easily established and fast growing, averaging about 4 ft. per annum when young.

Yields a useful medium quality softwood on a rotation of 35-40 years, in addition to intermediate yields of poles from thinnings. The wood is not inherently durable, and cannot be impregnated with preservatives as easily as most softwoods. This is the main drawback to its use for large-scale afforestation.

The tree grows well on most soil types, but is liable to die suddenly after some years if planted on shallow stony soil. It does not grow well in grassland, preferring forest soils. It grows in both dry and wet temperate areas.

Planting is usually done by means of transplants in wooden boxes, but in moist localities it is quite feasible to use bare-rooted plants. Seed averages about 100,000 to the lb. giving about 20,000 plants with normal nursery practice. Sowing should be done about six to eight months before the planting season or 5 to 6 months if lined out for planting with bare roots.

The side branches of cypress tend to persist for many years, and in order to obtain clean, knot-free timber it is necessary to prune regularly.

Cypress has proved susceptible to a canker disease (*Monochaetia unicornis*) in many parts of East Africa, especially in wet areas but this is not likely to prove serious in isolated small-scale plantations or farm wood-lots.

Yields vary considerably according to soil, but a good quality plantation should yield from 5,000 to 8,000 cu. ft. of timber at 35 years, plus about 2,000 cu. ft. in intermediate yields of small-wood.

It is commonly used as an ornamental tree, and makes a very neat clipped hedge.

REFERENCES

- [1] Wimbush, S. H.—"The Management of Cypress Plantations in Kenya", For. Dept. Kenya, Pamphlet No. 11, 1945. (Note.—The thinning and pruning schedules recommended are no longer in use, having been replaced by schedules contained in unpublished circulars. The main effect of these is to reduce the height of pruning from 38-44 ft. to 30 ft. and the number of thinning operations from eight to six on good sites and seven on poorer sites. Wimbush's recommendations may be regarded as the silvicultural ideal, which nearly always becomes simplified in the light of economic facts. The South African schedules for pines given in Part I, p. 113 represent the practical limit to simplification.)
- [2] Graham, R. M.—"Notes on the Growing of Cypress Timber on Farms", *E.A. Agr. Jnl.*, Jan., 1945, pp. 132-9.

Cupressus macrocarpa.—Very similar in characteristics to *C. lusitanica*, but is rather more coarsely branched and more susceptible to disease. *C. lusitanica* has entirely replaced it as a plantation tree, and in fact it is hoped to eradicate *C. macrocarpa* completely, to prevent it from hybridizing with the *C. lusitanica*.

Cupressus benthamii.—A species very closely related to *C. lusitanica* and not easily distinguished from it. There is a great deal of variation, and hybridization among the cypresses planted in East Africa, and most plantations are to some extent a mixture. It will be a long time before seed of guaranteed pure lines is available, but meanwhile the Forest Departments are endeavouring to preserve the purity of the best plantations and use only these for seed collection. The "*benthamii*" type of cypress is rather coarsely branched than "*lusitanica*" but not as conspicuously so as "*macrocarpa*". The bark also is rougher and more reddish. It is believed to be more resistant to drought and is therefore being used for planting in dry mountain areas.

Most of the older Forest Department plantations at Shume (W. Usambara), Olmotonyi and Narok (W. Meru), Mufindi (Iringa District) and near Mbeya appear to be of *benthamii* rather than *lusitanica* type. The best trees for seed collection are at Sungwe near Shume.

Cupressus sempervirens var. *pyramidalis*: Italian Cypress.—The tall narrow-crowned cypress commonly planted as an ornamental. May be raised from seed as with the other species of *cupressus*, but there are other varieties of *C. sempervirens* which have not the narrow monolith-like habit, and the seed does not always breed true. For ornamental use it is best to raise large plants 1-2 ft. high in big pots or tins, and reject any which do not show the proper form.

Suitable mainly for moist temperate areas, but is sufficiently drought-resistant to survive with only 35 in. rainfall at above 4,500 ft.

Eriobotrya japonica; Loquat: Japanese Medlar.—A fruit tree commonly planted in gardens in moist, temperate areas, where it becomes a spreading-crowned tree 30-40 ft. high. Its main interest as a forest crop, however, is the fact that it makes an ideal "withy" species for Native Area plantations. It is planted as a hedge plant by Wachagga for this purpose, and there are also unique plantations of it in the Kilimanjaro Forest Reserve planted 4 ft. by 4 ft. spacing to supply "fito" for native hut-building. The tree is easy to establish and produces

withies from coppice in about two years. It needs at least 45 in. of rain at an elevation of 4-6,000 ft.

EUCALYPTUS SPECIES. GUMS AND IRONBARKS, ETC.

There are many hundreds of species of *Eucalyptus* of which probably less than a dozen have been tried on any scale in Tanganyika. In the moist highland areas several species are capable of phenomenal growth giving trees 100 ft. high in about ten years. The timber of most species, especially of young, fast-growing trees is usually inclined to split, and difficult to work. The main value of Eucalypts is in providing tremendous yields of fuel, or of very straight poles. It is not uncommon for *Eucalyptus* plantations to yield 500 cu. ft. of fuel per acre per annum on short coppice rotations.

Most species are not very easy to plant. Only *E. citriodora* can be raised by direct sowing and then only in high rainfall areas. The seed of the others is minute and needs careful nursery technique. Planting should be done with potted plants whenever possible, never with bare-rooted stock. Stumps of *E. citriodora* and *E. robusta* have been used successfully in wet places, and in Uganda, striplings have been found possible, but not as a general practice.

Nearly all species are very susceptible to damage by termites, though deaths occur mainly in dry years, and only during the first year or two. If termites are very numerous *Eucalyptus* planting may have to be abandoned, but as it is often impossible to find other species as useful, it is usually worth making an effort to overcome this difficulty by digging out queens, gammexane treatment, using the best planting stock only, repeated blank filling, and so on. Gammexane applied at the rate of about $\frac{1}{2}$ oz. per plant appears to be adequate for the worst conditions. A deep planting hole should be dug to give the tree plenty of treated soil in which to develop a good root system, and the gammexane powder is then sprinkled all over the soil as it is put back in the hole. This treatment enables the plants to establish themselves but the effect of gammexane wears off after a few months, and unless the trees develop some immunity when established, the termites will return. They are capable of laying waste a plantation of one-year-old saplings 6-10 ft. high, though as a rule an adequate proportion survive. It was found possible to establish trial plots of several dry area species in Sukumaland in a very badly infested soil during the exceptional drought year of 1949-50 by means of

gammexane treatment. Heavy beeting in both long and short rains must be expected and allowed for.

Several of the more valuable *Eucalyptus* species, notably *E. globulus*, *E. maidenii*, and *E. viminalis* have in South Africa and elsewhere proved very susceptible to damage by an insect known as the Eucalyptus Weevil or Snout Beetle (*Gonipterus scutellatus*), the larvæ and adults of which can cause extensive defoliation which may prove fatal. This insect has limited the planting of susceptible species in South Africa although recently a considerable measure of control has been achieved by means of an imported parasitic wasp, *Anaphoidea nitens*. The weevil has been reported in Kenya and Uganda but so far does not appear to have reached Tanganyika. The parasite has also been introduced into Kenya in an attempt to control it.

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- [4] Kevan.—"Eucalyptus Weevil in E. Africa", *E.A. Agr. Jnl.*, July, 1946.
- [5] Leggat.—"Eucalyptus in the Urban and Rural Economy of Uganda", *E.A. Agr. Jnl.*, April, 1952.

Eucalyptus citriodora: Lemon-scented Gum.—A very fast-growing, clean-boled species, which in favourable situations can attain a height of 60 ft. in five years and over 100 ft. in less than 15 years though it does not grow to a very great diameter. It grows at least as fast as black wattle, but there is usually more variation in height between different trees. It is an ideal species for obtaining large-sized poles in very long lengths.

The timber is reputed to be of good quality suitable for farm carts, etc., but has not been used extensively in East Africa.

Although it grows best in moist temperate climates, *E. citriodora* is remarkably drought-resistant, and is surviving even in hot, lowland areas of about 30 in. rainfall. It would be very suitable for planting in alluvial or seepage areas in dry country.

It has a comparatively large seed for a eucalypt, and can be raised in normal years by direct sowing at least in localities having a fairly high rainfall. In dry country or difficult condi-

tions it is preferable to use potted transplants. The tree can be planted from stumps in favourable areas. Like most species of *Eucalyptus* it is very sensitive to attack by termites which are capable of destroying even vigorously growing saplings 6-10 ft. high. It coppices well, and in pole plantations can be regenerated simply by clear felling.

Eucalyptus globulus: Blue Gum.—A fast-growing tree which can also reach large dimensions, suited only to fairly moist conditions, e.g. 45 in. rainfall or more, about 4,000 ft., though at higher elevations it will grow with only 30 in. of rainfall. At Lushoto there is a large plantation believed to be about 50 years old which reached a height of 100 ft. in 1921. The volume was then estimated to be 5,100 cu. ft. per acre on the upper slopes and 8,900 cu. ft. on the lower slopes. The plantation would then have been less than 20 years old. The trees in 1952 were 150-170 ft. high but the volume per acre is not known.

At Mufindi (80 in. rainfall at 6,200 ft.) a 6-year-old plantation was 50-60 ft. high. On North Kilimanjaro an avenue 26 years old is 85 ft. high and healthy despite the low rainfall of about 30-35 in. at 6,500 ft. Another plantation at Longoi in W. Usambara, has grown well in even drier conditions (about 30 in. at 6,000 ft.).

When grown in plantations the tree is straight and usually of good form, but as an isolated or avenue tree it develops a large heavy crown and is liable to blow down when mature.

The timber is reputed to be hard, strong and fairly durable in Australia where it is used for heavy constructional work, poles, etc., but the trees in W. Usambara are mostly marred by having spiral grain.

This species is very susceptible to Snout Beetle damage. (See note under *Eucalyptus* spp.)

In Kenya it has been planted extensively for wood fuel for railway locomotives. Plots at Uplands (7,800 ft.) are reported to yield about 2,500 cu. ft. fuel per acre on a 9-year rotation from coppice, which is equivalent to about 4,000 cu. ft. stacked volume. These yields are probably below average.

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- Wimbush.—"Blue Gum Coppice for Wood Fuel", *E.A. Agr. Jnl.*, January, 1948.

Eucalyptus maculata: Spotted Gum.—A species related to *E. citriodora* but less drought resistant. It does not thrive in dry areas. Its rate

of growth is rather less than that of *E. citriodora* except in deep, moist soils with unimpeded drainage. The timber is used for wagons, carts, etc., and for tool handles, and with care can be used even for fine work.

It has not been planted much in recent years but there are old plantations of German origin in Lushoto, and Eastern Uluguru (45–50 in. rain at 4,500 ft.) which have grown well, mostly on valley sites.

Eucalyptus maidenii: Maiden's Gum.—A very popular species for pole and fuel plantations in mountain areas. Appears to be less exacting than most species in regard to soil, and has proved very suitable for afforestation in dry mountain grassland areas, such as Kasulu, W. Uluguru, and the Southern Highlands. It is the main species grown for fuel near Mbeya (33 in. at 5,750 ft.) where it does better than *E. viminalis*, *E. camaldulensis* or *E. saligna* on very poor pumice soils, reaching about 45 ft. in seven years. It is even growing fairly well around Iringa on impoverished "miombo" soils with a rainfall barely 30 in. per annum. Under marginal conditions, however, it is rather inclined to become diseased. In other countries, especially South Africa, it is no longer planted extensively owing to susceptibility to disease and Snout Beetle. (See under *Eucalyptus* spp.) There is a danger that disease may become serious if it is planted on a large scale in marginal areas, and alternative species for the Southern Highlands are badly needed.

It is fairly easy to establish by means of potted transplants. Seed averages about 120,000 per lb. and should be sown about five or six months before the time of planting out.

For poles or fuel it can be regenerated by clear felling on a rotation of 7–10 years, or less. The best plantations near Mbeya (Ipinda, 7,000 ft. with rainfall 45 in.) are reported to have yielded 13,000 stacked cu. ft. of fuel per acre after 13 years, i.e. 1,000 cu. ft. per acre per annum.

Eucalyptus microcorys: Tallow-wood.—Not very extensively planted, but there is a small plot of magnificent trees over 150 ft. high planted about 50 years ago on a good site near Lushoto. Worth planting elsewhere in similar localities. The timber is strong and durable, suitable for heavy work.

Eucalyptus paniculata: White or Grey Ironbark.—A rather slow-growing species (compared with other Eucalypts), with usually, a very straight bole. Fairly drought-resistant and there-

fore widely used in South Africa for fire-breaks in hot areas. The timber is durable but rather too hard for general purposes. An excellent species for durable poles, or for heavy constructional work. It has not yet been planted very much in Tanganyika.

Eucalyptus robusta: Swamp "Mahogany".—A large, usually fast-growing tree, often of spreading habit. It is suited only to moist situations, and is often planted on sites with sub-soil water in which it grows well provided the water is not stagnant. It does not withstand waterlogging as well as *E. camaldulensis* (*E. rostrata*) and will not grow in permanent swamp. It is suited to all altitudes down to sea level, given the right soil conditions. The timber is hard, red and durable.

This species has not been planted much in Tanganyika. A small plot at Mufindi (Iringa District) with 80 in. rain at 6,000 ft. is not outstanding, having reached only 75 ft. in 14 years. A plantation on S. Kilimanjaro (6,000 ft. with about 60 in. rainfall) reached a height of 20–25 ft. in three years.

Eucalyptus saligna: Sydney Blue Gum; Grey Gum.—One of the best species for highland areas or for moist sites in the lowlands. Extensively planted in South Africa for firebreaks to break up large blocks of pines, and also as a plantation species in its own right, mainly for pit-props. It is very fast growing, fairly drought resistant, and less liable to disease or beetle damage than most other eucalypts.

The timber is not as strong nor as durable as that of many species, but the bole is nearly always very straight, and it can be impregnated easily with preservatives, so that in many respects it is an ideal pole species. The timber is very liable to split on sawing, though this can be overcome to some extent by special sawing methods. It is fairly easy to work and often has a pleasant grain, and has been used for general joinery, flooring and even for furniture. It could be used for pulping if grown on an adequate scale.

In Tanganyika *E. saligna* has been planted mainly in semi-swamp areas around Bukoba, but there are small plots of it in several parts of the highlands. This species is less tolerant of marginal conditions than *E. maidenii* but in wetter places is at least as fast growing. At Mufindi (rainfall 80 in. at 6,000 ft.), a small arboretum plot reached only 90 ft. in 14 years, but a neighbouring plot in a better site dating from 1931 is about 140 ft. high and of excellent form. More recent plots in this locality are not

outstanding; one planted 1940 has reached 100 ft., another planted 1945 was only about 40 ft. in 1951 and much poorer than adjoining *E. maidenii*, and *E. globulus*, of the same age. It is possible that these were raised from seed of a poor strain collected locally and it seems advisable to use South African seed for future planting, although even in South Africa the botanical identity is in doubt. It has been confused with a closely related species, *E. grandis*. At Tukuyu (100 in. rainfall) there is an older plantation planted 1929 and 1930, which has grown very well indeed and is of good form, the height being 120-130 ft. in 1951. At Kifanya Mission on the Njombe-Songea Road (6,000 ft., 58 in. rainfall) trees reached 112 ft. in 16 years. *E. saligna* is one of the species which will no doubt be planted more extensively in future as an alternative to *E. maidenii*.

REFERENCE

Scott.—"The Utilization of *E. Saligna*", *S.A. For. Dept. Bull. No. 34*, 1940 (Rev. 1950).

Eucalyptus viminalis: Ribbon Gum; Manna Gum.—A large tree, fast growing, but often of poor form. The timber is very tough but not very durable and is useful only for rough work. The tree is very resistant to frost, and was therefore formerly planted extensively in the South African High Veld, around homesteads and for pit-props and rough timber. It needs fairly moist conditions for reasonable growth.

In Tanganyika it has grown well at Mufindi, Tukuyu, and in Bukoba District, but it has not done at all well under severe conditions at Mbeya (5,500 ft., rainfall 33 in.) on shallow pumice soil where *E. maidenii* is quite good. This species is very susceptible to Snout Beetle damage. (See note under *Eucalyptus spp.*)

Grevillea robusta: Australian Silky Oak.—A very useful, fast-growing timber tree, which has been planted extensively for shade over coffee. It grows well in the lower temperate zone in both wet and dry areas, but will not survive at very high altitudes. On Kilimanjaro for example its upper limit is at about 6,000-6,500 ft. It will survive in moist lowland areas (e.g. Morogoro township) but is not usually very happy below 3,500 ft. nor with a rainfall less than 35-40 in. It grows fairly well even on rather poor shallow soils, such as the Kasulu sands, and the Geita banded-ironstone soils.

The seed ripens in January and remains viable only for a few months. It must, therefore, be sown while still fresh. Planting is done by means of transplants, preferably potted, or in boxes.

Under favourable conditions its rate of growth is only slightly slower than that of wattle or *Acacia melanoxylon*. It has been planted on Kilimanjaro in strip mixtures with *Cupressus lusitanica*, and *Widdringtonia whytei*, with both of which it keeps pace fairly well, though tending to over-top the *Widdringtonia* in places.

The timber was formerly disregarded in Tanganyika, but wartime conditions revealed a ready market for it for railway sleepers. It is now accepted in East Africa for sleeper or baulk timber, also for shelving, packing cases, etc., being fairly light and easily nailed when green. It is somewhat difficult to season and work to a high finish, but, if sawn radially it reveals a pleasing grain, superficially resembling quarter-sawn oak. With care it can be used for fine work and has been so used for many years in Australia and elsewhere.

The tree has an erect habit of branching, and an attractive flower and foliage and is therefore a useful avenue tree. It coppices with only moderate vigour when young. When mature it could be regenerated fairly easily from natural seedlings, assisted by cultivation under the trees.

Hagenia abyssinica.—An indigenous tree occurring on many of the mountain ranges of Tanganyika, and especially characteristic of the Southern Highlands where it is the most used local timber. The tree is spreading, usually very branchy, with an extremely attractive feathery fresh green foliage, and reddish papery bark.

The timber is fairly hard, red, not durable unless treated and inclined to warp on drying, but in the absence of anything better is widely used in the Southern Highlands, for all purposes.

This species is by nature a pioneer tree of grassland or scrub in areas of destroyed temperate rainforest. It occurs mainly in open land often along water courses at above 6,000 ft. with a rainfall of 35 in. or more. It does not grow in heavy forest conditions and is not really suited to growing in plantations. It has been planted mainly to provide narrow belts of hardwoods to break up softwood plantations. It produces a heavy leaf litter and would be a valuable tree for covering steep slopes or water catchments.

In plantations the form is usually bad, either with heavy branches, or with several leaders. Close spacing and pruning is necessary to give clean boles, but the species is liable to be

badly checked or even killed if pruned heavily or crowded too much in marginal areas.

The seed is easily obtained in quantity but is difficult to extract from the dried flowers. The usual practice is to collect the dried inflorescences and sow the whole lot on a bed covered with a mulch. Seedlings need about six months in the nursery. Potted plants are normally used.

Hagenia grows rapidly for the first few years averaging about 4 ft. a year for the first 5-10 years. It can outstrip pines or cypress when young, but never reaches a great size. Mature trees are usually 50-60 ft. high. Girths of 15-18 ft. have been reported from Kenya, but this would be exceptional.

Juniperus procera: East African Pencil Cedar.—Occurs widely in the drier temperate forests of East Africa. Its chief merit as a plantation species is that the heart-wood, even untreated, is resistant to termites, and posts made from split logs are therefore highly valued for fencing. The timber is of commercial importance for the manufacture of pencils, and has also a pleasing colour and natural lustre which make it very suitable for panelling, doors, window-frames, etc. It is also widely used for shingles. The trunk, however, tends to be deeply fluted, often to such an extent that bark is enclosed within the heartwood forming focal points of decay. Mature trees are often defective, owing to heart-rot and insect borers, so it is not easy to obtain large dimensions of good timber. Medium-sized trees make ideal transmission poles.

As a plantation species its chief drawback is its slow rate of growth on the dry sites where it is most useful, averaging barely 18 in. per annum during the first ten years. In moist temperate conditions the rate of growth is faster but does not approach that of cypress. In Lushoto a plantation 43 years old is nearly 100 ft. high, the trees having a mean girth of 47 in. As an indigenous species, it should be a fairly safe investment for plantations in the drier temperate regions, where the behaviour of exotics is frequently unpredictable, though it would be difficult to justify as a commercial proposition, in comparison with cypress or the dry-area pines.

Seed ripens in March and in June-September and can be extracted from the fruit by drying and pounding in a native mortar. It should be sown at least eight months before planting time, and transplanted into pots or boxes.

Pencil Cedar was formerly planted extensively in the drier mountain areas, especially near Shume (W. Usambara) but has been given up in favour of the faster-growing exotics which also have better form. It was often planted in mixture with Brown Olive but it now appears that better form is obtained by planting it pure at close spacing (6 ft. by 6 ft. at the most) and thinning very slowly. By careful selection it may be possible to obtain seed strains which will produce trees without flutings, in which case cedar may again come into its own as a plantation tree.

Masopsis eminii: Muhumula (Kihaya).—An indigenous timber tree of the Nyanza Lake-Shore areas and of Bukoba District. Has been planted in Uganda and to a less extent in Bukoba District, where it is a common tree in native fields. Elsewhere in Tanganyika it has only been tried on a small scale. Suitable for the lower moist temperate zones. The timber is yellow, darkening to brown, light, tough, easy to work, and suitable for rough carpentry. Seed averages about 250 to 500 per lb., and ripens in August (at Amani).

It grows fairly rapidly (3-4 ft. per annum for the first four years on Kilimanjaro), and has usually a straight clean bole. Suitable for avenue planting, or as isolated trees.

Regenerates freely from seed, the fruits commonly being dispersed by hornbills. In Amani it has spread extensively from an old plantation and is becoming very common in more open parts of the indigenous forest. The Amani plantation is about 45 years old, and the biggest trees are 120 ft. high, with girths averaging about 5 ft.

Ocotea usambarensis: East African Camphorwood.—This is one of the most important timber species of the country, but has not been planted extensively, partly because seed is very difficult to obtain, and partly because in the natural camphor forests the old trees when felled send up a mass of root suckers covering a wide area around the stump. Replanting is therefore unnecessary. The timber is pale golden brown when freshly sawn but eventually darkens to chocolate-brown. It is fairly easy to work, but inclined to warp and split unless carefully seasoned. It is extensively used for furniture in East Africa.

The tree is suited only to fairly high rainfall areas at medium elevations (more than 45 in. rainfall at 4-7,000 ft.), and appears to prefer

light, overhead shade, though it grows satisfactorily in open plantations if the rainfall is high. Seed averages about 3,000 to the lb. It is not easy to obtain, and does not germinate well unless the outer pulp has been thoroughly cleaned off. Nursery stock is usually obtained by lifting natural seedlings or small suckers from the forest and raising them in banana fibre pots for a few months before planting.

The only plantations recorded in Tanganyika are at Uru (S. Kilimanjaro), where trees planted in 1945 were 12-25 ft. high in 1952, and at Magamba (W. Usambara) where trees planted in 1938 were up to 50 ft. high by 1952. The plantation at Uru was badly damaged by the honey fungus (*Armillaria*) but this must be most unusual, as natural suckers are never attacked even after very heavy felling.

Camphor is fairly fast growing especially from suckers, and should average at least 3 ft. a year in favourable areas, for the first 10-20 years. A provisional increment table compiled in Kenya suggests that camphor will reach a height of 80 ft. and 52-in. girth at 50 years, or 100 ft. and 81-in. girth at 75 years.

Although it appears that camphor can be grown in plantations it is likely to be planted mainly in light secondary forest or scrub such as the *Macaranga* forest which forms the lower fringe of Kilimanjaro, in order to hasten the natural process of invasion. Very limited trials indicate that it can be established easily under *Macaranga* but unless the canopy is lightened considerably the trees make very little growth.

PINUS SPECIES: PINES

The pines have not yet been planted very extensively in Tanganyika, but they will probably form the mainstay of future softwood planting, especially in mountain grassland areas. They have been used on a very large scale for afforestation in South Africa, parts of which very closely resemble the moist temperate areas of Tanganyika in regard to altitude, vegetation, soil and in the amount and distribution of rainfall.

In the past, the introduction of pines has been hampered by the difficulty of securing adequate mycorrhizal inoculation, and many trial plots have suffered in consequence. Mycorrhizal soil can now be obtained from several localities in Tanganyika, but is still a limiting factor in some areas where large-scale planting is being developed.

The pines appear to be more suited to planting in grassland than cypress which does best in cleared forest sites. They are capable of withstanding competition from grass or low shrub, if the rainfall is not too low. In mature short grassland pines can be planted directly into small pits and require no further weeding. In long grass or forest scrub it is necessary to slash the weed back to ground level and burn off before planting. Five or six weedings may be required, but it is not essential to clear the land completely, although of course the initial rate of growth is much greater in land that has been hoed.

Pines should always be planted by means of transplants raised in pots, boxes, or the "Swaziland" type of bed. If bare-rooted plants are used the effect of mycorrhizal inoculation is likely to be lost, at least in dry areas. In very moist localities, especially on old forest soils, inoculation seems to be less essential, and it is possible that bare-rooted plants, or even direct-sown seed might be successful.

The species which can be recommended for planting, on the basis of South African experience, in order of importance are the following:—

P. patula.—This is the chief species used for softwood and pulpwood planting in the "summer rainfall" regions of South Africa, and is the one showing most promise in Tanganyika. It is not one of the very drought-resistant species, and grows best at altitudes above 5,000 ft. with a rainfall in excess of 60 in. It will, however, grow quite well in much drier conditions, provided the soil is deep and fertile. At high elevations (7,000 ft.) it grows well in mist belt areas with a rainfall less than 30 in. and will also survive at elevations as low as 3,000 ft. with a rainfall of about 40 in. In dry areas on shallow soil it is liable to be killed by drought in very dry years. It is very fast growing, second only to *P. radiata*, and on good sites reaches about 45 ft. in eight years, and 110 ft. in 30 years. The total yield per acre, including thinnings, is usually about 8-10,000 cu. ft. The timber is very light, and rather soft, especially from immature trees, but has been found very suitable for all the general purposes for which softwood timber is required, except heavy construction.

The foliage is considered to be very ornamental, and the tree when young has rather spreading branches which rapidly smother grass, forming a closed canopy in about four

years, provided the trees do not check. The species is very susceptible to damage by fire, and by hail. If damaged, it may become infected by "Diplodia" disease, caused by the fungus *Sphaeropsis pinea*, but is less sensitive to this disease than *P. radiata*. It is also liable to damage by rats until four years old when growing in grassland, but appears to be less frequently attacked than *P. caribaea*. When mature it regenerates itself very freely from seed.

Seed averages from 20-25,000 per lb. and germinates easily. The young seedlings have rather a tendency to damping off, especially if kept too moist or too heavily shaded. It is best to sow in boxes at a rate not exceeding 2 oz. per square yard and to use no shade. It requires about 10-12 months in the nursery, possibly even longer in very cold areas. This species is more susceptible to mycorrhizal deficiency than most (in Tanganyika) and unless heavily inoculated may check badly in the nursery. When this happens growth usually occurs only in patches, giving a very mixed batch of plants, some 1 in. high and yellow, others 12 in. high and vigorous.

P. radiata (*P. insignis*): Maritime Pine.—This is the fastest growing of the pines, and produces a very good quality softwood, but, although it has been planted very extensively in the "winter rainfall" regions of South Africa, and in New Zealand it cannot be recommended for extensive afforestation in Tanganyika. It is essentially a species of the "Mediterranean" type of climate and when grown in "summer rainfall" areas in, for example, the East Transvaal, it is very susceptible to the disease known as "Diplodia" caused by a fungus *Sphaeropsis pinea*. In Tanganyika a small plot at Old Moshi (Kilimanjaro) planted in 1945 grew very well for about five years reaching 30 ft. but then became diseased after pruning. It has now recovered to some extent. An older plot at Mufindi (Iringa) is also unhealthy. Both of these areas have a very high rainfall, and it is possible that in drier places the species may remain healthy. Trees growing at Ipinda (Mbeya) and at Shume (Lushoto) with a rainfall less than 40 in. are more promising, apart from a few unexplained deaths. There is also a small plot at Magamba (Lushoto) where the rainfall is about 45 in., which has attained a height of 100-120 ft. in 24 years, with girths averaging about 5-5½ ft. at breast height.

This species is therefore one of the most promising for this country in suitable conditions but is too uncertain for use on a large scale, to the exclusion of other species.

Seed averages about 15,000 per lb., and the seedlings require only about 7-8 months in the nursery. It requires mycorrhizal inoculation but has given much less trouble in this respect than *P. patula*. Farmyard manure appears to be adequate.

P. caribaea: Slash Pine.—A species native to the south-eastern states of the U.S.A., where it is valued as a timber for pulpwood and as a source of resin, which is obtained by tapping mature trees. The timber is harder and heavier than that of *P. patula*, and more suitable for constructional work, except that it has a tendency to contain "compression wood", which may cause planks to twist or split after sawing. The form of the tree is usually good.

It has been widely planted in South Africa, as an alternative to *P. patula*, especially at lower elevations (3,000-4,000 ft.) or on hotter aspects, as it is definitely more drought resistant. It grows equally well, however, at 6,000 ft. It grows very rapidly during the first few years and very quickly becomes established even in dense grass or scrub. It appears to be less troubled by mycorrhizal deficiency than the other pines, and is not affected by "Diplodia" disease. The chief drawback to this species in South Africa when planting in dense vegetation is its liability to damage by rodents which frequently nibble the bark away completely at the base of the trees. The damage only occurs during the first three years, and is usually confined to limited areas. This species is also rather susceptible to damage by the *Armillaria* fungus if growing on old forest or scrub land. When mature it is not easily killed by fire.

The rate of growth is usually slightly less than that of *P. patula* and the volume production is also lower. It has only recently been introduced into Tanganyika and the above information is based entirely on South African experience. There is a small plot at Old Moshi (Kilimanjaro) planted in 1946 which was 20-25 ft. high in 1951 and looked promising.

The seed is larger than *P. patula* seed, and germinates over a longer period. Up to 6,000 plants are usually obtained from 1 lb. of seed, which should be sown about ten months before planting.

The taxonomy of *P. caribaea* is in some doubt. The species usually planted is the "Northern Slash Pine" which may actually be *P. elliottii* Engelm., the true *P. caribaea* Morelet being the "Southern Slash Pine", a much inferior species. There is also a variety in British Honduras, which has recently been renamed *P. hondurensis* Loock.

P. pinaster.—This species, like *P. radiata*, is usually more suited to a "Mediterranean" climate, but it has grown well in other rainfall zones in South Africa, and has proved to be a useful species for planting on dry sites or shallow soils. It is almost as fast growing as *P. caribaea* or *P. taeda* on good soils. Its chief drawback is the difficulty of obtaining seed which can be guaranteed to produce straight trees. There are many strains and most of them are crooked. The best appears to be what is known as the Portuguese strain.

The timber is of good quality, and rather heavy for a softwood. The species has not been planted in Tanganyika until very recently.

P. pseudostrobus.—A Mexican species not yet introduced into Tanganyika, but mentioned here as it is now being planted widely in South Africa in areas suited to *P. patula*. It is almost as fast growing as *P. patula*, and has a good form with long internodes, but the bole tends to be rather swollen at the branch whorls. It is important, therefore, not to delay pruning operations. The timber is of good quality unless weakened by the nodes of unpruned branches. Seed is not very easy to obtain at present, as the entire South African supply is being used locally. The seed produces about 7,000 plants per lb., and should be sown about ten months before planting.

P. palustris: Longleaf Pine.—A species very similar to *P. caribaea*, with which it occurs naturally in Florida. The timber is very similar, and it also yields resin. In its natural state it tends to occur on drier sites than *P. caribaea*, but in South Africa has not shown the same adaptability to a wide range of conditions, and is not particularly successful in the summer rainfall highland area. It is exceptionally resistant to damage by fire which accounts for its tendency to occur in drier sites than *P. caribaea*. Even as a seedling it can survive a grass fire.

The tree is usually very straight, especially when young, with few lateral branches. It is not very easy to establish owing to a tendency to "stick" at ground level for several years

after planting. Usually, however, it gets away in the second or third year and is then about as fast growing as *P. caribaea*.

P. taeda: Loblolly Pine.—Another American species similar to *P. caribaea* in appearance and also planted fairly extensively in South Africa, but is now rather out of favour. The tree is decidedly sensitive to drought, more so even than *P. patula*, and the form of the trees is inclined to be variable; some stands are very good, others rather twisted or forked. The timber is of medium density, but rather brittle, and is not considered as good as *P. patula*. The tree grows about as fast as *P. caribaea*. It casts a dense shade, and is very resistant to damage by hail or wind. A small plot at Old Moshi reached a height of 15-20 ft. in six years. The seed produces about 8,000 plants per lb.

Other species which may be expected to grow well in the moist temperate areas of Tanganyika include:—

P. montezumæ.—A species closely resembling *P. pseudostrobus* but more coarsely branched.

P. khasya (*P. insularis*).—A fairly fast-growing species, which grows well in many places, but is usually of very bad form. A small plot reached 45 ft. in 14 years at Mufindi (Iringa). An adjacent plot of *P. patula* reached 60 ft. in the same time.

P. Leiophylla.—Fairly promising, usually of good form but has a tendency to produce epicormic shoots, which make it difficult to grow knot-free timber.

The species of pine mentioned above are all fast-growing trees which should be suitable for timber production in the moist temperate highland areas of Tanganyika. They should also grow on drier sites in the highlands, especially if mist-belt conditions are prevalent and if the soils are deep and fertile, but they cannot be recommended for very dry country.

There are in addition, many species of pine which will grow in much drier conditions, and produce timber, but the rate of growth is very much lower, and quite insufficient to justify afforestation on a large scale. The following species are considered the most suitable for trial, but none of them has been planted on a sufficient scale in Tanganyika to enable one to predict their behaviour with any certainty:—

P. canariensis: Canary Island Pine.—An attractive tree, usually with a very straight bole, and a tendency to develop epicormic shoots. It is slow growing, except on the very best sites

and does not produce much diameter growth. It is therefore more of a pole than a timber species. The timber is of good quality. It is very resistant to drought, and to fire, and unlike most pines it coppices with unusual vigour when clear-felled. It prefers a "Mediterranean" type of climate, which does not occur in Tanganyika.

P. halepensis: Aleppo Pine.—Also a Mediterranean species, which is renowned for its ability to grow on poor shallow soils, provided they are not too acid. It prefers soils rich in lime. The form is frequently rather poor, but there is a good strain, *P. halepensis* var. *bruttia*, seed of which is obtainable from Cyprus. It is showing promise at Shume (W. Usambara) and Olmotonyi (W. Meru).

P. longifolia: Chir Pine.—An Indian species capable of growing on very shallow soils in the Himalayas, and yielding both timber and resin. It is rather slow growing but very resistant to drought and to fire. It has not been planted in Tanganyika for long enough to judge how it will do, but in comparable areas in South Africa it has been rather a disappointment, having proved unsuited to elevations above about 4,000 ft. The timber also, which is normally of good quality and high density, very suitable for constructional use, has been found to contain a high proportion of spiral grain in South Africa. Seed should, therefore, be obtained from India for planting in East Africa. It is thought that this species will prove suitable for afforestation on the drier sides of mountains in Tanganyika. The rate of growth is slow, and may be only 1 ft. per year for the first five years, but later on the trees grow more rapidly. It is planted by direct sowing in India, but nursery stock should be used in East Africa to ensure mycorrhizal inoculation. The seed produces about 3,000 plants per lb.

Podocarpus spp.: Podo.—There are several indigenous species which are an important component of the upper moist temperate rain-forest areas of for example, Kilimanjaro and the Usambaras and also of the Bukoba swamp forests. The short-leaved species, *P. usambarensis* and the closely related *P. gracilior* have been planted on a small scale in various places, including temperate grassland areas such as Kasulu. On N. Kilimanjaro where it occurs naturally, plantations of *P. gracilior* have not been very successful. All species are slower growing even than East African Cedar and very considerably slower than the cypresses or the pines. At Magamba (W. Usambara) plantations 25 years old are about 50 ft. high (about

half the height of *P. radiata* of the same age). *Podocarpus* species are very tolerant of shade, and *P. usambarensis* has been underplanted beneath old East African Cedar plantations in W. Usambara. The rate of growth beneath a canopy is very slow indeed, barely 1 ft. a year, but the trees are healthy and of good form.

The timber is a typical medium-quality softwood, and is not sufficiently superior to cypress for these species to be recommended for large-scale afforestation except for the probability (which is by no means a certainty) that indigenous trees will be more suited to the environment and freer from disease than an exotic. They may prove useful for underplanting poorly stocked natural forest.

The seed usually germinates with difficulty, and over a long period, which makes it difficult to raise an even crop of transplants. Seed is collected in most places between November and March (September in Bukoba). Planting is usually done with potted stock, but the seedlings transplant fairly easily.

The short-leaved Podos are handsome foliage trees, and despite their slow growth have been planted as ornamentals in several townships, including Lushoto and Bukoba.

Populus spp.: Poplars.—Several kinds of poplars (e.g. *P. canescens*, *P. deltoides*, *P. Wislizenii*) have been introduced in recent years. They are suited mainly to areas above 4,500 ft. having either a high rainfall (50 in. plus) or subsoil moisture. With a moist, but not stagnant subsoil they will grow at lower elevations. Under good conditions the rate of growth is phenomenal, often exceeding 10 ft. a year.

The timber is light and soft and is extensively used in other countries for making matches. In South Africa, poplars are planted to fill up moist valleys in large softwood plantations. Good logs command a very high price. In Tanganyika there is unlikely to be any demand for logs unless enough is planted to warrant opening a factory. The timber of *P. canescens* is light but tough and is used for planking, boxes, etc.

Poplars cannot be planted from seed and are nearly always raised in a nursery from cuttings, which strike easily. Many species, especially *P. canescens*, produce masses of root suckers which can be lifted for planting. Limited numbers of cuttings or suckers could now be obtained from Uru (S. Kilimanjaro), Lushoto, Mbeya, Mufindi, and a few other places. The

trees are usually planted out in the form of large striplings and require pruning for the production of good logs for peeling.

Pygeum africanum.—An indigenous tree of moist temperate forests occurring as an occasional tree in most highland areas. It is common also on forest edges and native fields adjoining forest. It can attain a height of 80 ft. with a girth of about 10 ft. but large trees are not common. The crown is dense, and heavy, and the foliage is an attractive shining green. It would make a good shade tree. The timber is hard, red and durable, but is liable to split or warp on drying. It has been used for rough purposes.

In Tanganyika it has been planted mainly on Kilimanjaro. Wachagga preserve trees in their *shambas* and use them as a source of withies. The trees are cut at a height of 4-6 ft. from the ground, and then produce masses of straight pollard shoots. As a plantation tree it has been tried successfully on Kilimanjaro and W. Usambara. Planting is usually done with potted natural seedlings. It is faster growing than *Rapanea* but not as fast as *Hagenia*, averaging about 2 ft. a year.

Rapanea rhododendroides.—An indigenous tree of moist temperate rain-forest commonly associated with *Ocotea*, *Podocarpus*, and *Syzygium*. It is usually a tall, rather slim-boled tree of good form. The timber is not durable but young trees are commonly used as building poles by the Wachagga. The wood has thick medullary rays like *Grevillea* and is quite ornamental if sawn radially, though the pale brown colour is not particularly interesting. It has been used mainly for floor-blocks and for rough work. It needs to be seasoned carefully to prevent twisting and splitting.

Rapanea has been planted on a very small scale in W. Usambara and S. Kilimanjaro, using natural seedlings lined out in a nursery for a few months. It responds well to plantation technique, but is very slow growing. It could only be planted economically with the aid of squatters as it is necessary to keep it clean for five years or more. Periodic creeper cutting would be necessary for an even longer period.

Trees planted in a very high rainfall area on Kilimanjaro reached a height of only 10-15 ft. in eight years. In W. Usambara growth was if anything slower in a 40-45-in. rainfall area at 6,500 ft.

The main interest of this species (and of *Syzygium*) in plantations is the possibility of planting it to restore indigenous forest by artificial means. In many mountain areas fast-growing exotics, especially conifers, are subject to disease, and there are often good reasons for preserving or restoring the natural vegetation. It appears that a forest closely resembling the natural forest but of greater value, composed of *Rapanea*, *Syzygium*, *Podocarpus*, etc., could be re-created with the aid of squatters at a reasonable cost. If *Ocotea* were used as well it would need to be introduced in groups some years later, or it would outstrip the other species.

Schinus molle: Pepper Tree.—An ornamental tree having a very attractive drooping foliage. The leaves have a hot peppery taste. Not a very large tree, but individual specimens may reach 40 ft. or more with a large spreading crown. Fairly drought resistant; a few trees even manage to survive in favoured spots in Sukumaland (30 in. at 4,000 ft.) though subject to termite damage and liable to die-back after some years. Suited mainly to areas having over 30 in. of rain at about 6,000 ft. or over 45 in. above 3,500 ft. The seed averages about 8,000 to the lb. and germinates easily. Potted plants are recommended for ornamental planting. If watered in a garden, the tree will reach 8-10 ft. in a year.

Syncarpia laurifolia: Turpentine Tree.—A large straight-boled tree related to *Eucalyptus* having a very dark, dense, symmetrical and pyramidal crown which persists almost down to the ground even when mature. The tree is, therefore, useful as an ornamental foliage tree, or for windbreaks, avenues, live firebreaks, etc. The timber is reddish and durable but warps and splits on drying. It is tolerant of shade, and fire-resistant, and can be clipped to form a hedge.

It is fairly drought-resistant but grows best in moist, temperate localities. In Tanganyika the only recorded plantation is at Tukuyu (100 in. rainfall) where a plantation about 20 years old is about 50 ft. high, with girths averaging 40 in. on marginal trees. Other trees occur at Mufindi (E. Iringa) and Lushoto. It would be worth trying in drier mountain areas. It has been planted in South Africa as a marginal row around pine plantations to serve as a solid hedge for arresting sparks, but the rate of growth in most places (2 ft. a year) is too slow and the trees are usually overtopped by the conifers. It has failed in moist

"miombo" country in N. Rhodesia. Recently planted trees at Mufindi (90 in. rain) have begun well, making 4 ft. growth in the first year, despite a heavy growth of grass and bracken.

Local seed is in short supply. It is usually raised in pots or boxes like a *Eucalyptus*, but requires rather longer in the nursery.

Syzygium sp.—An indigenous tree of moist, temperate rain-forest, occurring with *Rapanea*, *Ocotea*, and *Podocarpus*. The bole is not usually very straight and often slightly buttressed, reaching larger diameters than *Rapanea*. The timber is hard and fairly durable but is liable to split. It has been used for rough work.

It has not been widely planted but there are trial plantations on S. Kilimanjaro and in W. Usambara. The tree grows well in plantations but slowly, not much faster than *Rapanea*. Planting was done with natural seedlings lined out in a nursery for a few months. (See note under *Rapanea*.)

Tristania conferta: Brisbane Box.—A straight-boled symmetrical-crowned tree resembling and related to *Syncarpia*, but with less dense foliage. The wood is strong and durable. The only recorded trees in Tanganyika are at Amani (75 in., 3,000 ft.), where a line of trees reached an average height of 50–60 ft. in ten years, the girths averaging 30 in. These conditions are probably ideal for it, but it should make a useful pole species in moist, temperate areas. Older trees at Amani have continued this good growth and are very straight boled, but their age is unknown.

Widdringtonia whytei: Mlanje Cedar.—A Nyasaland conifer resembling a cypress, and yielding a good quality softwood. Similar to *C. lusitanica* in its requirements and characteristics. It has been planted fairly extensively in Tanganyika as an alternative to cypress in the expectation that it would be freer from disease. In most places it has grown well but not usually as well as cypress. Several 5–10-year-old plantations on the wetter parts of Kilimanjaro, planted on recently cleared forest land, have been very seriously depleted by the Honey fungus (*Armillaria mellea*), which in places has destroyed about 20 per cent of the trees, and threatens to spread. It should be noted, however, that nearly all species tried in this area have been attacked, and it is probable that fungus damage would not be serious in drier areas free from rotting stumps. It has grown quite well in dry grassland on poor soil in the Southern Highlands, for example at Njombe (40 in. rain at 6,000 ft.) where cypress remains stunted.

The tree is slower growing than cypress but averages 3–4 ft. per annum for the first five or six years on favourable sites. It can be planted in the same manner as cypress, but requires rather longer in the nursery.

It is a very ornamental tree, especially when young, having a juvenile foliage reminiscent of a spruce. It is, therefore, the best tree available in E. Africa for use as Christmas trees. The juvenile leaves are replaced by the typical "cypress" type of foliage after a few years. It makes an attractive hedge.

PRELIMINARY NOTE ON THE ALKALOIDS AND TOXICITY OF *SENECIO RUWENZORIENSIS* S. MOORE

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(Received for publication on 1st July, 1953)

Senecio ruwenzoriensis S. Moore (ragwort) has been suspected of causing poisoning in cattle in Kenya for many years. In 1934 a farmer near Timau lost several imported stock kept in a paddock where this plant was plentiful. The symptoms described, and the liver lesions found in one animal, were similar to those produced by other species of *Senecio*. Feeding trials were carried out at Kabete using cattle, sheep and rabbits but were all negative (Hudson, 1944).

In 1950 there was another case of suspected Seneciosis from this area and the liver sections showed the typical changes associated with Senecio poisoning.

During 1952 on the same farm at Timau, now under different ownership, *S. ruwenzoriensis* was again suspected of causing the death of an imported bull; unfortunately liver specimens were not available for examination.

Specimens of the plant were submitted to Kabete for examination and one of us (M.L.S.) has isolated two new alkaloids, *ruwenine* and *ruzorine* (Sapiro, 1953). An initial test in rats indicates that *ruwenine* is the more toxic of the two and is also more toxic than *retrorsine* (from *S. retrorsus* D.C.).

It is hoped to carry out full-scale feeding trials with the plant, which is being grown in the poisonous plant garden at Kabete. Determination of the chemical structure of the alkaloids is being done elsewhere.

The object of this note is to warn the farming public in East Africa that this plant should be regarded with suspicion and, as far as possible, eradicated from pastures.

Botanical Note (P. J. Greenway)

Herb 18 to 30 in. high with typical groundsel-like yellow flowers and smooth, silvery-green, slightly fleshy leaves up to 3½ in. long. Distribution above 4,000 ft. altitude in Uganda, Kenya and to South Tanganyika.

The disease in cattle in South Africa is known as "Molteno Cattle Disease" and is essentially a chronic poisoning developing only after stock have been exposed to infested veldt for a considerable time—at least a year according to Steyn (Steyn, 1934).

Symptoms

Persistent diarrhoea, staring coat, inappetence, straining which may become very intense; animals may go down in a comatose state or become hypersensitive and frenzied; ultimately coma and death two to four days after onset of symptoms.

Treatment (Steyn, 1934)

There is no known specific antidote, and when decided symptoms have developed very little can be done, on account of the liver damage which has taken place. The animal should not have access to the plant and should be fed on easily assimilable foodstuffs. The function of the liver should be stimulated by administration of glucose or other carbohydrates.

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NOTES ON EAST AFRICAN APHIDS

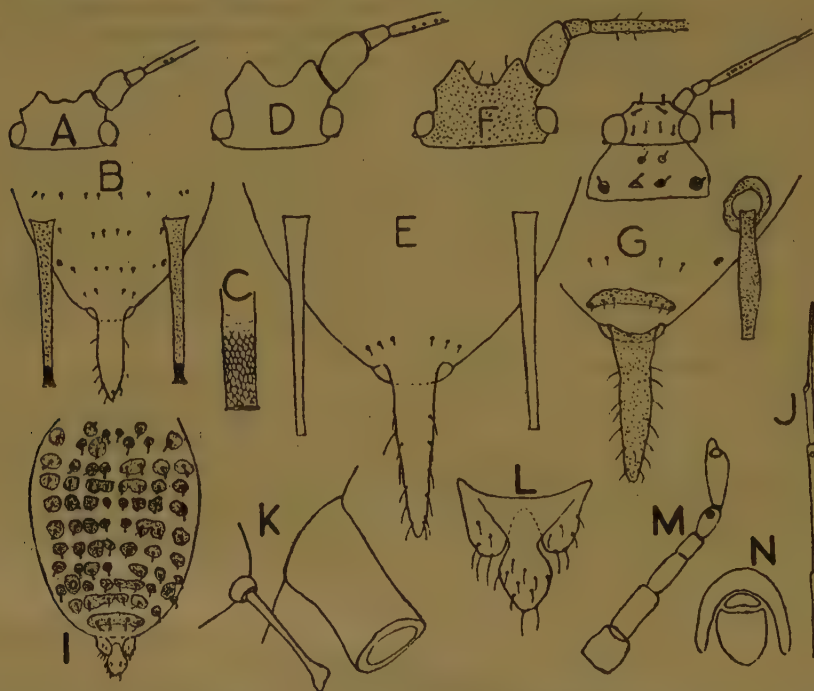
IV—APHIDS OF LEGUMINOUS CROPS

By V. F. Eastop, East African Agriculture and Forestry Research Organization

(Received for publication on 12th July, 1953)

One root-feeding and five leaf- and stem-feeding aphids are described here. *Trifidaphis phaseoli* (Pass.), a white globular aphid without siphunculi and with short legs and antennae, occurs on the roots of many dicotyledons in addition to *Leguminosae* and is sometimes a pest of potatoes. This aphid, like a number of other root-feeding *Fordini*, has the cauda and sub-anal plate placed dorsally and enclosed on three sides by the inverted U-shaped eighth tergite (Fig. N). *Macrosiphum nigri-nectaria* Theobald is known only from East Africa and occurs most commonly on cow pea, *Cajanus indicus*. This aphid differs most obviously from *M. euphorbiae* (described in Part II of this series) by the completely black siphunculi and the short antennal hairs. *Acyrtosiphon pisum* (Harris), a large green aphid with a long green cauda and long slender green to dusky siphunculi without hexagonal

reticulation at the apices, occurs on many legumes as does *Aphis craccivora* Koch, the vector of groundnut rosette. *A. craccivora* is not figured as it resembles *A. gossypii* (figured in Part II) except that *craccivora* is a shiny black aphid in life while the black forms of *gossypii* are dull. *Therioaphis* spp. are recorded from many countries (but not yet East Africa) as pests of legumes, particularly clovers, mostly under the name *T. ononidis*. It is not known how many of these ornate black and yellow or black and white aphids occur in Africa. The species figured here (Figs. H-L) is *T. (Pterocallidium) maculatum* (Buckton). *Megoura viciae* Buckton, a large bright-green aphid with jet black legs, long cauda and swollen siphunculi, is not recorded from East Africa but is common on *Leguminosae* in other parts of the world.



A-C, *Macrosiphum nigrinectaria*, A, head; B, posterior end of abdomen; C, enlargement of apex of siphunculus. D and E, *Acyrtosiphon pisum*, as for A and B. H-L, *Therioaphis maculatum*, H, head and prothorax; I, remainder of thorax and abdomen; J, apical antennal segments; K, enlargement of siphunculus and capitate hair borne on abdominal tubercle; L, enlargement of knobbed cauda and bilobed anal plate. M and N, *Trifidaphis phaseoli*, M, antenna; N, eighth tergite, cauda and anal plate.

STEM BORERS OF CEREAL CROPS AT KONGWA, TANGANYIKA, 1950-52

By J. C. Duerden, Overseas Food Corporation, Tanganyika

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The annual loss of grain caused by stem borers is probably in the region of 50 per cent in a year of heavy infestation. This loss is brought in three main phases; many seedlings are destroyed, the yielding capacity of the plant is reduced by the material damage to the stem, and extensive lodging may occur just before harvest. Two species of stem borers have been found at Kongwa and it appears likely that the carry-over from season to season is maintained in crop residues remaining after harvest and in volunteer and actively regenerating sorghum.

Of the numerous methods of control examined at Kongwa a system of dry season burning of stubbles showed the greatest promise. Only small numbers of borers have been found in the base of the plant throughout the dry season and no migration of larvæ towards the root appears to occur. Consequently the base of the plant can largely be neglected in burning operations. Experimental control by means of insecticides was not very successful but may be effective if carried out universally in any one area.

Maize and sorghum are the principal cereal crops within the scope of operations of the Overseas Food Corporation at Kongwa in the Central Province of Tanganyika and it is on these two cereals that the studies of stem borers described below have been carried out. Other graminaceous crops such as millet and sugar-cane are attacked by stem borers and Mally (1920) states that stem borer larvæ have been found attacking two wild grass species, Johnson grass (*Sorghum halepense*) and Sudan grass (*Sorghum sudanense*) farther south in Africa. At Kongwa two species of stem borers have been found in both maize and sorghum. They are *Busseola fusca* Fuller and *Chilo zonellus* Swinh. The former is the well-known Stalk Borer or Top Grub, a very serious pest of maize in South Africa, whilst the latter, which is a new specific record for the African Continent, is a common sorghum and sugar-cane borer in India. The two species exist side by side in the same field, probably in the same plant, and the damage caused is exactly similar.

Extent and Nature of Damage

A considerable loss of yield from cereal crops is experienced as a result of stem borer attack. Estimates of this loss vary greatly from place to place and from season to season but in South Africa the average annual loss to the maize crop of the whole country is about 10 per cent (Du Plessis and Lea, 1943) and as high as 25 per cent in some cases (Mally, 1920).

An experiment to determine the loss of maize caused by stem borers was carried out at Kongwa in 1952. A complete control of borers was maintained by weekly applications of D.D.T. dust to one set of plots whilst a second set remained unprotected. The final yield was 1,916 lb. of grain per acre with complete control of stem borers as compared with 1,326 lb. per acre from the unprotected plots. The difference was significant at the 1 per cent level of probability and represents an increase in yield of 44 per cent with control of borers. The general level of infestation on the untreated plots was fairly low, approximately 30 per cent of the plants being attacked by some 3,400 borers per acre whereas the treated plots were completely free from stem borer infestation.

The ultimate loss in yield is a cumulative effect of a series of separate forms and stages of loss due to the activity of the borers. The first infestation occurs about two weeks after planting when the plants are about 6 in. in height. The young borer larvæ feed on the leaves and stem of the plant and many young plants are killed with a consequent loss of stand. In South Africa, Mally (1920) estimates this reduction in the plant population of maize as high as 75 per cent in some cases. At Kongwa in 1952 a reduction of 10 per cent of the plant population occurred during the first month after planting. Between then and harvest a further 4 per cent of the plants were lost due to the activity of the borers. With sorghum at Kongwa over 30 per cent of plants were lost due to borers in the first five weeks after planting in the same year.

Following the initial attack the pest bores down into the stem tunnelling both vertically downwards and horizontally across. It is this latter activity which gives a characteristic line

of puncture holes or perforations across the leaves when they are, at a later stage of growth, extended from the stem. This boring within the stem restricts the passage of plant nutrients in addition to the obvious material damage to the plant. Consequently a state of general depletion of the plant is brought about which is reflected in lower yielding capacity.

In the experiment on complete control of stem borers by means of frequent applications of D.D.T., described above, an attempt was made to measure the separate forms of increase in yield obtained by complete control. It appeared that the 44 per cent increase was made up of over 40 per cent increase in the weight of cobs per acre together with an increase of 3 per cent in the amount of grain per cob. Much of the increase in weight of cobs per acre is attributed to the depletion of the plant by a normal infestation of borers when no control is practised, but in the experi-

ment there was an increase of 7 per cent in the number of cobs per plant on those plots where control was maintained over the unprotected plots.

As plant maturity and harvest is approached a further detrimental effect becomes important. The mechanical strength of the plant is much reduced by the continuous activity of the borers and considerable lodging results just before harvest. This falling of the plants is particularly disadvantageous with a mechanically harvested grain crop such as sorghum and a further loss in yield is experienced and harvesting difficulties greatly increased.

Degree of Infestation

Considerable fluctuations in stem borer populations and levels of infestation occur during a season, from year to year and from one area to another. The broad seasonal variations over three years are shown in Table I.

TABLE I—COMPOUNDED TABLE OF GENERAL LEVELS OF STEM BORER INFESTATION, 1950–52

Season	Crop	Percentage Plants infested	Infested Plants per acre	Larvæ per acre	Pupæ per acre
1949–50	Maize	30	1,600	2,000	400
	Sorghum	35	8,000	12,000	1,200
1950–51	Maize	45	3,000	5,000	900
	Sorghum	90–100	81,000	350,000	50,000
1951–52	Maize	30	2,000	3,400	—
	Sorghum	35	9,000	14,000	—

The 1950–51 season crop carried a high population of stem borers, particularly in sorghum, and yields suffered in consequence. During the 1949–50 and the 1951–52 seasons the level of infestation was lower but still sufficiently heavy to cause considerable losses in final yields of grain.

A survey of stem borer infestation in a considerable proportion of the cereal crop was carried out during the 1949–50 season. The fields in which samples were taken were, in

most cases, over one mile apart and were both planted and sampled at different dates. Contour fields of maize were divided into eight approximately equal parts. In each eighth the numbers of plants in two separate one-chain lengths (22 yards) of row chosen at random were counted to determine the plant population. From each eighth 20 plants were removed at random for stem borer analysis. This consisted of dissecting each plant and counting the numbers of stem borer larvæ and pupæ present. The results are presented in Table II.

TABLE II—INCIDENCE OF STEM BORERS IN MAIZE IN THE 1949–50 CROP

Variety	Date of planting	Date of count	Age of plant at sampling in days	Percentage plants infested	No. of plants infested per acre	No. of larvæ per acre	No. of pupæ per acre
Kenya Yellow	28 Dec.	23 Feb.	57	0	0	0	0
Kenya Yellow	6 Jan.	2 Mar.	55	1.9	150	1,070	0
Katumbili	7 Dec.	22 Mar.	74	22.5	1,780	1,980	400
Kenya Yellow	14 Feb.	15 May	90	33.8	1,350	1,980	400
Kenya Yellow	8 Feb.	14 Jun.	126	17.5	1,540	2,090	330

In the two fields sampled in late February and the beginning of March no pupæ were present. No larvæ were present in one field, and about 1,100 per acre in the other. In plants sampled after the middle of March a total of about 2,400 larvæ and pupæ were present per acre, consisting of roughly 2,000 larvæ and 400 pupæ. This total was similar in three

different fields planted at widely different dates with different varieties.

In sorghum a somewhat similar survey was carried out. Contour fields were again divided into eight approximately equal parts and in each eighth a ten-link length (2.2 yards) of row was taken at random and all the plants were removed for stem borer analysis. The results are presented in Table III.

TABLE III—INCIDENCE OF STEM BORERS IN SORGHUM IN THE 1949-50 CROP

Variety	Date of planting	Date of count	Age of plant at sampling in days	Percentage plants infested	No. of plants infested per acre	No. of larvæ per acre	No. of pupæ per acre
Westland Milo	21 Jan.	16 Mar.	54	0	0	0	0
Dobbs ..	24 Jan.	30 Mar.	65	9.2	2,900	5,700	400
Kalo ..	22 Feb.	6 Apr.	43	3.8	1,100	4,300	0
Oklahoma ..	28 Feb.	18 Apr.	48	22.6	5,000	12,900	400
Westland Milo	21 Jan.	8 May	107	29.2	6,800	12,100	400
Dobbs ..	24 Jan.	8 Jun.	135	29.2	6,800	7,900	1,100
Kalo ..	22 Feb.	12 Jun.	110	30.6	5,400	5,400	1,400
Westland Milo	15 Feb.	22 Jun.	127	46.6	12,100	18,900	2,500
Oklahoma ..	28 Feb.	3 Jul.	125	40.6	10,000	14,300	700

The infestation reached a far higher level than in maize but the main build-up came later in the season (and in the life of the plant). On 16th March no borers could be found in sorghum whereas they were present on 2nd March in maize. From 30th March to 12th June the numbers of infested plants rose slowly to 5,000 to 7,000 per acre, with combined larvæ and pupæ counts ranging from 4,300 to 12,500. On 22nd June and 3rd July, however, the number of infested plants was 10,000 to 12,000 per acre, with 15,000 to 21,400 larvæ and pupæ per acre.

From both maize and sorghum surveys it appears that the most consistent relationship is that between the numbers of larvæ and pupæ per acre together with the percentage of plants infested and the time of season as expressed by the date of sampling. Such factors as time of planting, age of the plant and variety appear to have little effect on the infestation of stem borers.

Seasonal Biology and Movements Within the Plant

The first brood of eggs is laid soon after the germination of the particular cereal attacked, when the plants are about 4 in. in height. The egg masses are deposited by the female either under the edges of the leaf sheaths which form

the outer layer of the stem of the developing plant or on the upper parts of the "funnel". This latter is the cavity or depression formed at the apex of the stem by the whirl of leaves in developing cereals before the head-bearing stem elongates up the centre. The eggs hatch and the larvæ move up to the extended leaves of the plant where they feed for a short time. At this stage a redistribution of larvæ takes place. Many larvæ move to adjacent plants and more uniform distribution of infestation in the field results. After this initial migration the larvæ commence boring into the stem, some moving down through the base of the funnel and others entering through the layers of leaf sheaths laterally into the stem. It is during this initial feeding and boring stage that most of the reduction in plant population occurs and if the plants are not strongly established by this time the losses in plant numbers are much increased. The remainder of the larval period is completed within the stem where pupation takes place. In most cases before pupation the larvæ appear to bore a hole laterally through the stem to the outside which is loosely plugged with small particles of plant tissue. This is presumably done in order that the adult moth may effect an exit to the open air and in so doing will not sustain damage to its wings.

During 1951 an analysis was carried out to determine the fluctuations in stem borer populations at weekly intervals in the same field. A 15-acre contour field was planted with maize on 18th January, but owing to slow germination stem borer counts were not commenced until 2nd March. Every week four samples of 50 plants, each plant taken at random, were removed from the field and dissected and the numbers of stem borer larvæ and pupæ in each plant were counted. The cobs were harvested by hand during the first week of July and the counts continued throughout the dry season until the commencement of land preparation in December for the 1951-52 season necessitated the destruction of the remaining maize stalks. The fluctuations in population are shown in Fig. 1.

Five peaks of larval infestation occurred during the season at approximately four-week intervals, the last peak coming after harvest. From the middle of July onwards the numbers of larvæ gradually fell from 2,000 per acre to just below 1,000 during the latter half of November and December. Three peaks in the numbers of pupæ occurred, with possibly a fourth on 12th June, again at intervals of approximately four weeks. During September and October pupæ were rarely found, under 100 per acre being recorded, but from November onwards the numbers of pupæ increased slightly, probably corresponding to the fall in the numbers of larvæ at that time.

An adjacent field of approximately the same acreage was planted with sorghum early in February and sampling and analysis were commenced on 9th March using the same method as with maize described above. The heads of sorghum were harvested by hand during the third week of July and the counts continued through the dry season. A high population of borers remained in this sorghum field and in November it was felt that it constituted a serious threat to the following season's non-entomological research programme and consequently the sorghum was destroyed and the analysis discontinued. The population variations are shown in Fig. 2.

The peaks of larval infestation do not show as clearly as with maize but probably five peaks do, in fact, occur with sorghum after harvest as in maize. The second peak probably occurred during the period comprising the last few days of April and the first few days of May. The numbers of larvæ again fall throughout the dry season but during November at

least 100,000 per acre were still remaining. The pattern of the seasonal incidence of pupæ in sorghum appears different from that in maize, only one obvious peak occurring. A general decline appears to take place in the numbers of pupæ after the middle of May with possibly two minor peaks occurring, one on 7th June and the other on 28th June. From August onwards pupæ were always found but in comparatively small numbers, usually under 3,000 per acre.

From Figs. 1 and 2 it appears likely that small numbers of adult moths emerge during the dry season. In order to determine whether this was so, a small plot of sorghum was planted in early September, 1951. In order to be able to irrigate this plot it was necessary to site it at least a mile from the nearest fields of cereal crop residues and separated from such fields by a strip of dense thorn bush. In the middle of December half the plants were pulled up and dissected for a stem borer analysis. This showed that 9 per cent of the plants were infested with active stem borer larvæ but no pupæ were found. In January the remainder of the plants were dissected. Of these, 25 per cent were found to be infested, 4 per cent containing pupæ.

The graphs further indicate that the carry-over of the pest from one season to the next is maintained largely in the stems remaining in the fields after harvest, particularly in sorghum stubbles. During the dry season the number of sorghum stems increases both from the regeneration of existing plants which tiller extensively as a result of the removal of the main head during harvest and from volunteer plants arising from fallen seed. These plants remain green on the small quantities of moisture available and provide food for the larvæ of the post-harvest generation.

At the end of 1950 a survey was carried out to determine the numbers present in a field in which sorghum had been grown. Ten quadrats each of 20 ft. square were pegged out at random. All the plants in each square were removed and counted, regenerated, and volunteer plants being counted separately. The plants were then dissected and the numbers of larvæ and pupæ counted. There were 33,000 plants per acre of which 63 per cent had regenerated from old sorghum plants; 5,850 plants per acre were infested with 10,200 larvæ and 830 pupæ per acre. Both larvæ and pupæ were found in both regenerated and volunteer plants.

In the dry season of 1951, counts of plant and borer populations were carried out as part of an experiment on stem borer control by the burning of crop residues which is reported below. In this case, 46,000 plants per acre were actively growing in the field. Of these, 4,600 were infested with 5,000 larvae and 500 pupae per acre.

Du Plessis and Lea (1943) state that late in the season a migration of larvae from the upper regions of the plant towards the root takes place. It is suggested that the cause of this downward movement is the fall in temperature which occurs at that time of year. As the distribution of both larvae and pupae in the stem may be an important factor in control measures their relative positions in the stem were followed during a season at Kongwa.

In the weekly analysis of the fluctuations of stem borer populations carried out in 1951 and described above the height in the stem of each larva and pupa found was recorded. For purposes of convenience the stem was divided into four zones: base, first foot, second foot and above. In maize the base was taken as the part of the plant comprising the proximal end of the tap root and the part between this and the ring of adventitious roots formed just above ground level. In sorghum the base was taken as the root knot formed at the point of origin of the main shoot and the tillers. The first and second feet were the respective distances up the stem from the upper limit of the base and higher than two feet was classified as above. This latter zone contained the tassel in maize and the head in sorghum. The positions of borers in the stems of maize are shown in Figs. 3 and 4 and of sorghum in Figs. 5 and 6.

No downward migration of larvae either during the growing or dry season is apparent. The fact that this movement does not occur may be due to the absence in the Central Province of Tanganyika of cold climatic conditions similar to those occurring in South Africa.

Throughout the year the great majority of larvae and pupae in both maize and sorghum stems were found above the base, in most cases above the first foot. The comparatively small number of larvae and pupae present in the base of the plant during September and October suggests that the destruction of the aerial parts of the plant residues during these months may be a practical means of stem borer control whereas the base could largely be neglected.

Control Measures

Numerous aspects and methods of control of stem borers have been examined at Kongwa with varying degrees of success. The majority of these may be classed as cultural control methods in that they come, broadly, within the scope of the normal, or slightly adjusted, sequence of agricultural operations or treatments carried out during the complete annual cycle of producing a cereal crop. It will be convenient to consider each in its normal agricultural sequence.

Ploughing

Du Plessis and Lea (1943) carried out experiments in which maize stems containing larvae were buried in the ground at depths similar to those which would be achieved by the ploughing in of crop residues. They found that stem borer moths were able to emerge from depths of up to 4 in. although considerable mortality was effected. Thus the control by ploughing can only be partial. At Kongwa, difficulties were experienced in attempting to bury cereal crop residues and on no occasion was a complete burial of all the trash achieved. In addition, the ploughing of soils which have a strong tendency to compaction during the dry season is not possible until after the first rains towards the end of December. By this time the emergence of adult moths in considerable numbers has probably already taken place. Consequently it would appear that the reduction in the infestation of early-planted cereals as a result of ploughing in stubbles of previous cereal crops would be small.

Trap Crops

A control system based on trap cropping by the early planting of a cereal and its subsequent destruction is not generally applicable in an area with a short rainy season as at Kongwa. However, a small field was planted with maize on 28th December, 1951, in order to determine whether an early and rapid build-up of stem borers could be induced. The field was immediately adjacent to a field of sorghum stubble remaining from the previous season, the growing crop of which had suffered from a heavy attack by stem borers between 90 and 100 per cent of the plants having been attacked by harvest. The last week of December appears to be about the earliest date that maize can be planted at Kongwa. A plant population of 8,800 plants per acre was obtained.

By 7th February, 41 days after planting, only 10 per cent of the plants were infested with 1,800 larvæ per acre. It is at this stage of the season that a trap crop would need to be destroyed, either by deep ploughing, grazing or making silage. The level of infestation was too low to recommend trap cropping as an effective control measure against stem borers. Twenty days later, 29 per cent of the plants were infested with 7,800 larvæ and 440 pupæ per acre. This would be a more suitable level of infestation at which to destroy a trap crop but by this time the main maize crop had over 10 per cent of the plants infested with over 1,000 larvæ per acre.

Varieties

Studies of varietal differences in the degree of stem borer attack have largely been confined to sorghum as the range of types available for examination was very much greater than that of maize. During the 1950-51 season 41 varieties of sorghum, ranging from double dwarf to semi-giant types, from replicated variety trials were examined after harvest for the amount of stem borer infestation. All the plots were stooked and harvested by hand, only the heads being removed. Approximately one-quarter, taken at random, of the bulked

stems from each plot were dissected and every plant from every plot was found to have been attacked by stem borers. Thus of the types of sorghum examined no varietal differences in the degree of infestation by stem borers were found.

As described above the activity of borers within the stem increases the amount of lodging as plant maturity is approached. From this aspect a certain varietal difference has been observed. The stronger-stemmed varieties when heavily infested do not tend to fall as extensively as the thinner- and weaker-stemmed types.

A plot of an American inbred variety of maize, P8, claimed by the vendor to be resistant to attack by the European Corn Borer (*Pyrausta nubilalis* Hb.) was planted next to a plot of Kenya Yellow, the standard maize variety of the area. Both plots were planted on 10th January, 1952. Plant populations of 9,700 for P8 and 8,600 plants per acre for Kenya Yellow were established. Plants from both plots were removed and examined for stem borers periodically. The monthly means of percentage infestation and borers per acre are presented in Table IV.

TABLE IV—MONTHLY MEAN PERCENTAGE INFESTATION AND BORERS PER ACRE IN TWO VARIETIES OF MAIZE

MONTH	P8 INBRED		KENYA YELLOW	
	Percentage infested plants	Borers per acre	Percentage infested plants	Borers per acre
January	16	1,554	8	1,034
February	18	8,480	9	2,816
March	33	6,603	20	4,654
April	16	1,748	11	1,824
May	16	1,554	16	1,379

The American inbred variety was, in most cases, more heavily infested than the standard variety both in the percentage of infested plants and in the number of borers per acre and showed no resistance to infestation by the local species of stem borers.

Spacing

A maize spacing trial was carried out in 1951. It was planted on 8th January and eight different spacings between the plants in the row were examined. The extremes were 16 and 38 in. between the plants which gave plant

populations of 4,400 and 10,600 plants per acre respectively. After harvest the stems of the plants in the four centre rows of each plot were examined for stem borer infestation. There was considerable variation between plots but it did not appear to be associated with the different spacings. The mean infestation for the different plant populations varied between 60 and 70 per cent.

Fertilizers

Stem borer analyses were carried out on two phosphatic fertilizer experiments in 1950 to

determine whether the variations in the rate of the development of the plants produced by different amounts of phosphate influenced the degree of borer infestation. Sorghum was the test crop. The heads were harvested by hand and the stem borer analyses carried out after harvest. The results are presented in Table V.

TABLE V—THE EFFECT OF THE AMOUNT OF PHOSPHATIC FERTILIZER ON STEM BORER INFESTATION OF SORGHUM

RATE OF APPLICATION IN CWT. P ₂ O ₅ PER ACRE	PERCENTAGE OF PLANTS INFESTED	
	Experiment 1	Experiment 2
None	59.5	60.7
0.1	66.2	64.7
0.2	60.8	51.6
0.4	78.6	60.3
0.6	74.9	76.7
Mean	68.0	62.8
Significant differences 5%	15.9	18.3
1%	21.4	24.7

No important differences consistent between the two experiments occurred.

Time of Planting

Experiments on the planting at regular intervals of maize from 12th January to 15th March and of sorghum from 11th January to 15th March showed no association between the date of planting and the percentage of plants infested by stem borers at harvest. The maize plots had between 60 and 90 and the sorghum 90 to 100 per cent of the plants infested.

Grazing

There is some risk that animals fed on sorghum stubbles may suffer from cyanide poisoning and therefore a grazing trial of sorghum was not conducted, although the method may be satisfactory with suitable varieties of sorghum and beasts tolerant to cyanide. A trial was, however, carried out with maize crop residues but although a herd of 100 cattle remained in the field of stubble for almost seven weeks and devoured much of the dried leafy material, very few stems were eaten and then only the upper third of the plant was taken. This was, presumably, because of the exceedingly hard nature of the stems. Weekly stem borer counts revealed virtually no reduction in borer populations due to the activities of the cattle.

Burning

Dry-season destruction of cereal stubbles by burning would provide for the more or less complete eradication of the reservoir of stem borer infestation remaining for the following year. As stated above, the base of the plant, which is often difficult to destroy, could largely be neglected as the number of borers in this zone was negligible.

During the dry season of 1951 most of the stubble remaining from cereal crops on one farm, Farm 2, was destroyed by burning. On another, Farm 1, the trash was left standing in the field until most of it was ploughed in after the first rains at the end of December. These two farms were separated from each other and from other farms in the area by at least four miles of uncultivated land and bush-covered country. Just before the maize harvest of the following season 20 samples of 50 maize plants each were taken at random from both Farms 1 and 2 and a stem borer analysis carried out. The plant population per acre on each farm was also counted. The results of this survey are given in Table VI.

TABLE VI—THE EFFECT OF BURNING CEREAL CROP RESIDUES ON THE INFESTATION OF STEM BORERS THE FOLLOWING YEAR

	Farm 1 (stubble left)	Farm 2 (stubble burned)
Number of plants per acre	7,400	5,800
Number of infested plants per acre	1,100	560
Number of attacked plants per acre	2,020	900
Percentage infested plants	14.9	9.7
Percentage attacked plants	27.3	15.5
Number of borers per acre	1,150	740

Infested plants were those which had one or more borers in the stem at the time of counting, whereas attacked plants were infested plants together with plants in the stems of which a borer had been at a previous stage but was no longer present.

The results of this survey indicated that the disposal of cereal stubbles by burning, if practised thoroughly and universally, may provide a satisfactory level of control of stem borers. Consequently it was necessary to examine various methods of stubble treatment in order that effective burning could easily be accomplished.

It was found that maize stalks, when thoroughly dried, will not burn in the fields in the state in which they are left after hand or mechanical picking at the normal plant spacing. If the maize is stooked the heaps of stalks, when dry, can be fired successfully after picking. Where the method of harvest employed has left the plants in their growing positions the only successful method tried for destroying the plant residues was to windrow the stalks by hand. The best results were obtained with large windrows aligned, as far as possible, parallel to the direction of the prevailing wind and then fired either up or down wind. In this trial a few stems, when pulled, broke off at the first or second node but 180 of the stumps so formed were dissected and only one stem borer larva and one pupa were found out of a previous infestation of about 20 per cent plants infested. Most of the windrowed stems were completely destroyed by the burning but of the few charred stalks which remained none contained live stem borers.

With sorghums, two important factors, variety and spacing, influence the method of stubble treatment before burning by which plant residues can be destroyed. Even a closely spaced field of a dwarf variety when dry will not burn as it is left after combining as the small quantity of plant material is insufficient to carry the fire. Similarly a semi-giant variety sown in rows 28 or more inches apart will not fire in the field as left after combining. In both these cases it was found that if the stubble was uprooted and windrowed in lines parallel to the direction of the prevailing wind it could be almost completely destroyed by burning these rows. A mechanical method of doing this has been evolved. It consists of uprooting the stubble with a one-way disc set to a shallow depth followed by a side delivery rake which moves the trash into rows. Each windrow is built up until it is of sufficient size to burn without a break before the next is started.

A field trial of this method was carried out in 1951 in an 18-acre field of stubble of a dwarf variety of sorghum, Westland Milo, sown in 28-in. rows. The plant population and the amount of stem borer infestation were counted on 22nd September and the field was disced and raked before the end of September. The windrows were fired early in October and plots of one chain (22 yards) square taken at random were marked out after firing. This size of plot was chosen in order that each plot would include a portion of at least one fired windrow. All the pieces of stem remaining in

the plots were collected and dissected to determine the numbers of stem borers not killed. The results are presented in Table VII.

TABLE VII—THE EFFECT OF MECHANICAL SORGHUM STUBBLE COLLECTION AND BURNING ON STEM BORER POPULATIONS

	Before treatment	After burning
Number of plants per acre	46,000	—
Number of infested plants per acre	4,650	—
Number of larvæ per acre	5,170	22
Number of pupæ per acre	530	1

The combined total of live larvæ and pupæ remaining after burning represents a reduction of 99.6 per cent in the original stem borer population. Thus the level of control of the dry season population of stem borers was very high and, in addition, the field was left in a very clean state for the following season.

When semi-giant varieties of sorghum are sown in rows 14 in. or less apart no inter-row cultivations are carried out. Consequently a dense cover of plant material of both sorghum trash and weeds results. It was found that such a field when thoroughly dry will fire after combining without further treatment. In a trial under these conditions the burning tended to be somewhat erratic but between 60 and 70 per cent of the stubble was destroyed. In addition to the destruction of the stubble the heat generated near to stems which were not actually burned appeared to cause the death of a number of borers. In the trial the combined larval and pupal population of 7,300 stem borers per acre before firing was reduced to 1,450 borers per acre after burning. This represents a reduction of 80 per cent in the original borer population. From this trial it appears that provided a satisfactory level of yield can be attained with closely spaced semi-giant types of sorghum the post-harvest firing of the standing stubble may be an effective and economic method of stem borer control.

In addition to the methods of cultural control which have been examined at Kongwa insecticidal treatments have been tried. In 1952 an experiment comparing the effects of D.D.T., Derris and Parathion on the population of stem borer larvæ in sorghum was carried out. The D.D.T. was applied by hand as a 3 per cent dust at a rate of 20 to 25 lb. per acre. The Derris was applied in the form of a 0.5 per cent liquid emulsion and the Parathion a

0.1 per cent water solution. Both were applied by means of a hand sprayer at a rate of 20 gallons per acre. All treatments were carried out three weeks after planting. Samples of 50 plants per plot, taken at random, were removed at weekly intervals and the numbers of stem borers counted. The results are presented in Table VIII.

TABLE VIII—THE EFFECT OF THREE INSECTICIDES ON THE NUMBER OF STEM BORER LARVÆ PER ACRE

Days after treatment	D.D.T.	Derris	Parathion	Control
3	220	1,758	1,538	3,296
10	5,494	3,296	1,538	4,615
17	7,032	2,198	6,812	5,384
24	8,131	5,714	10,109	9,120
31	10,548	9,010	7,691	7,911

The level of control on all treatments was unsatisfactory; D.D.T. appeared to give the best initial control but the build-up of larvæ appeared to be slightly delayed by Derris and Parathion, particularly the former. Under the conditions of the experiment it is possible that the presence of untreated sorghum near the treated plots produced, by cross-infestation, a more rapid rise in stem borer populations than would occur if universal insecticidal treatment was carried out under field conditions.

Only one parasite of stem borers has been found at Kongwa. This is a pupal parasite and has only been reared from the pupæ of *Busseola fusca*. It is a species of *Chasmodon* (Ichneumonidae) but, judging from the small numbers which emerged from laboratory incubations it appears unlikely that any form of control of stem borers by artificially increasing the numbers of this parasite will be possible.

Discussion

It has been shown that, although large seasonal variations occur in the populations of the two species of stem borers found at Kongwa, there is a considerable annual loss of grain caused by the pests. This loss may be as high as 50 per cent in a year of heavy infestation. It is brought about by a reduction in plant population, a direct reduction of the yielding potentialities of the plant as a result of the material damage caused by the borers and

extensive lodging at harvest. An increased rate of seeding may obviate the losses in plant population and stronger-stemmed varieties reduce the numbers of fallen plants at harvest, but a direct method of control of the insect is required to reduce the material damage to the plant, particularly as this is probably the greatest source of loss.

As the main carry-over of the pest through the dry season appears to be in cereal stubbles remaining in the fields after harvest some form of dry-season destruction of both the trash and the pest is indicated. The almost complete eradication of stem borers achieved in the 1951 burning trial together with the encouraging results obtained by stubble burning on Farm 2 suggest that the dry-season burning of crop residues is the best method of control so far examined.

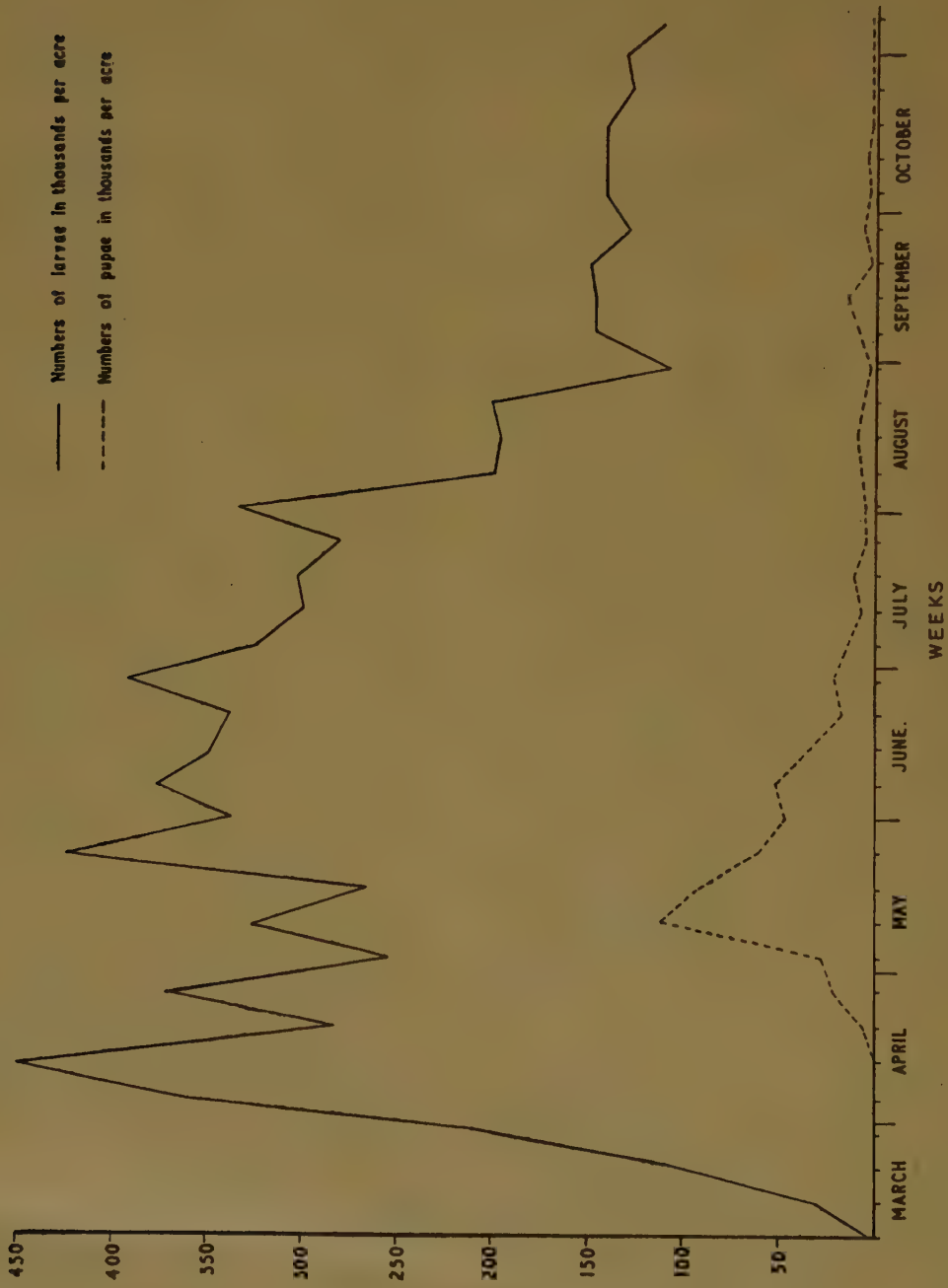
Treatment with insecticides is a further possibility but as it appears desirable to deposit the insecticide inside the funnel of the developing plant, as the majority of larvæ move through the funnel during some part of their life cycle, hand application is almost a necessity. Once the larva has bored into the stem it is almost immune from the normal insecticides and consequently the insecticide would have to be applied before the downward migration of larvæ commenced. The period between the germination of the crop and this migration is short and the application of insecticides to large acreages by hand is a slow process. In consequence it cannot be recommended as being a very satisfactory method of control.

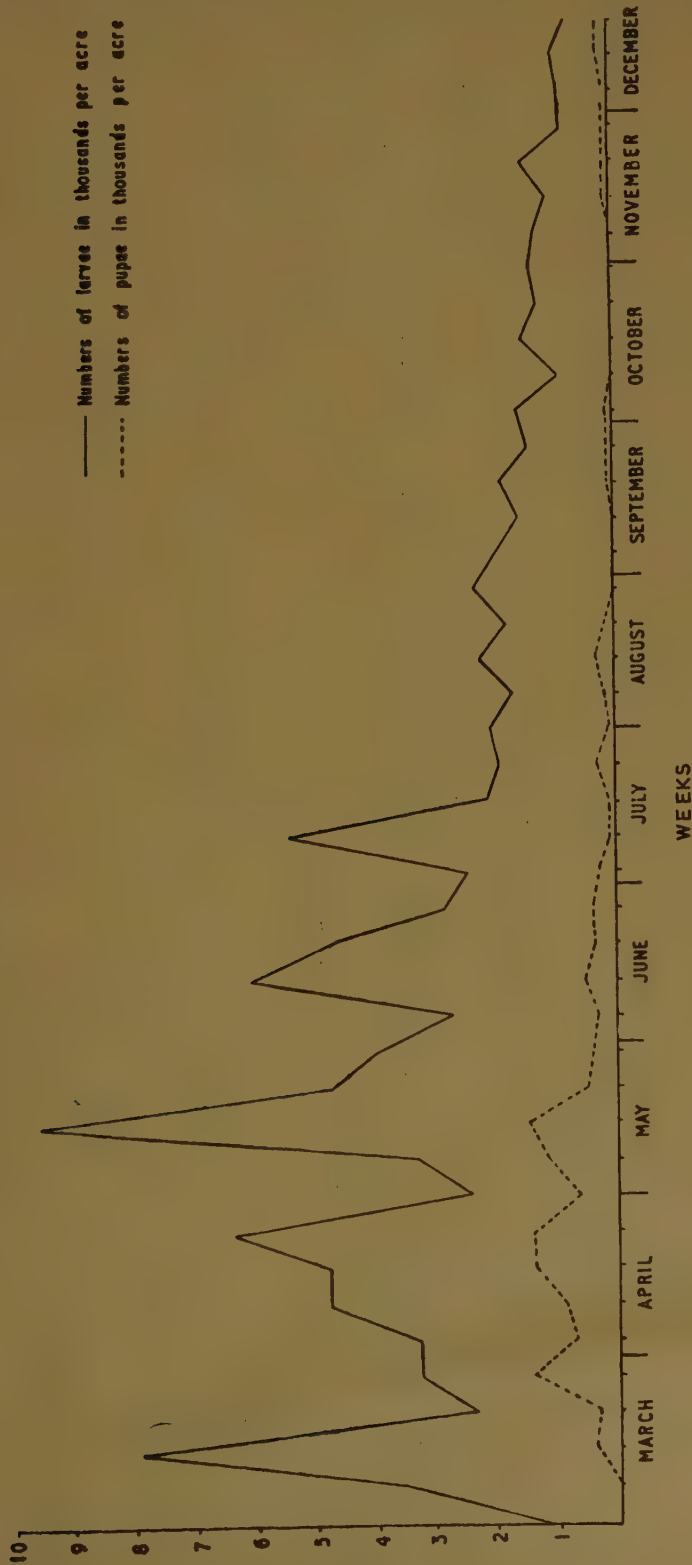
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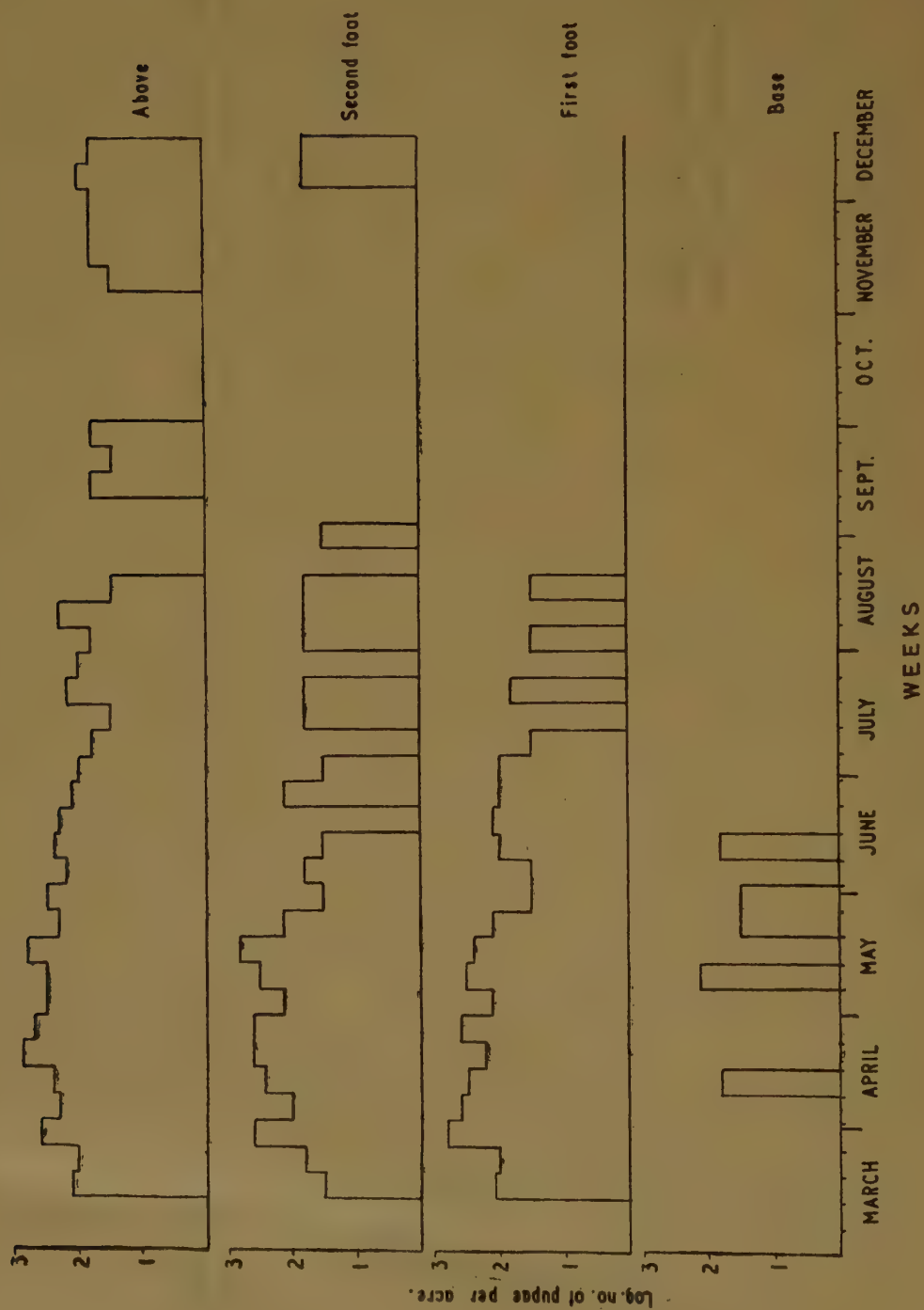
I wish to thank Dr. A. C. Evans for much help throughout this work and members of the staff of the Experimental Station, Kongwa, and of the Scientific Department of the Overseas Food Corporation for assistance. I am also grateful to the Commonwealth Institute of Entomology for identifying specimens for me.

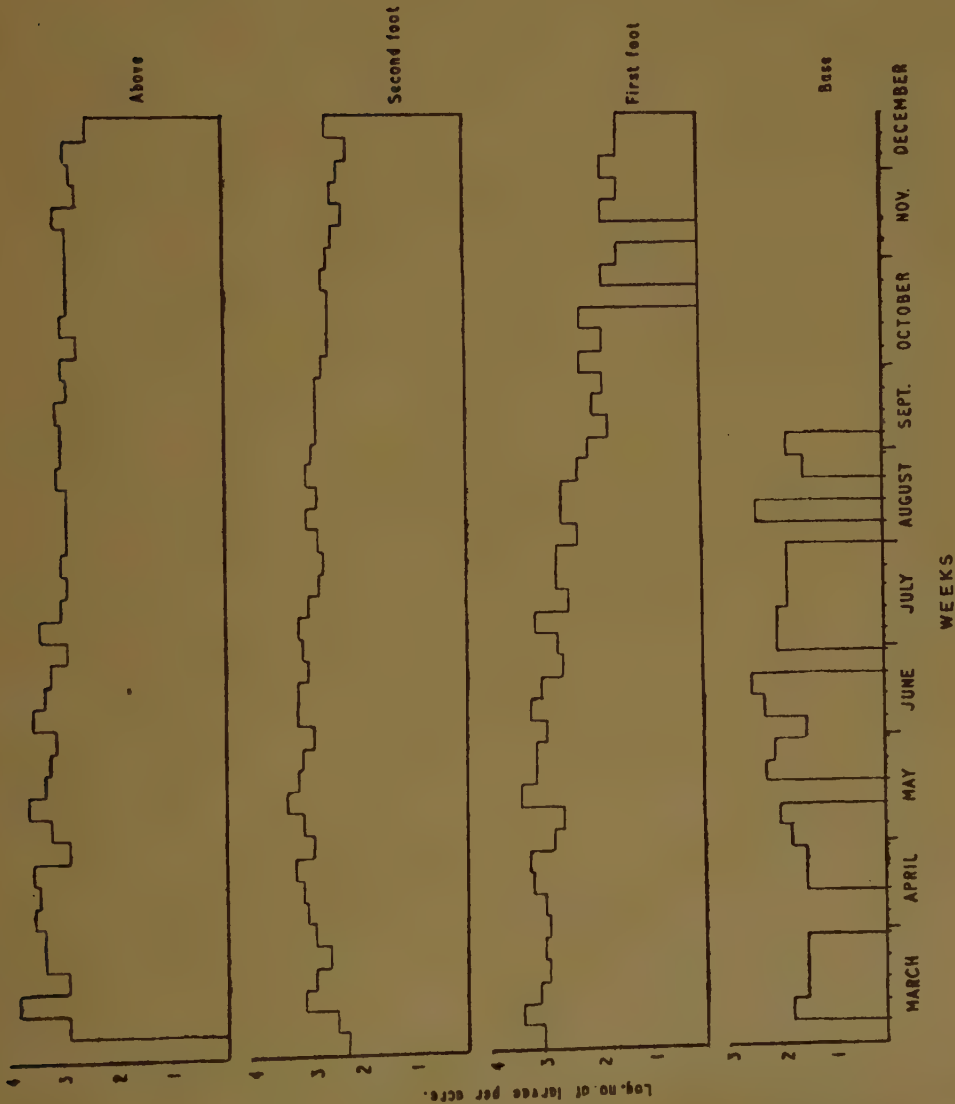
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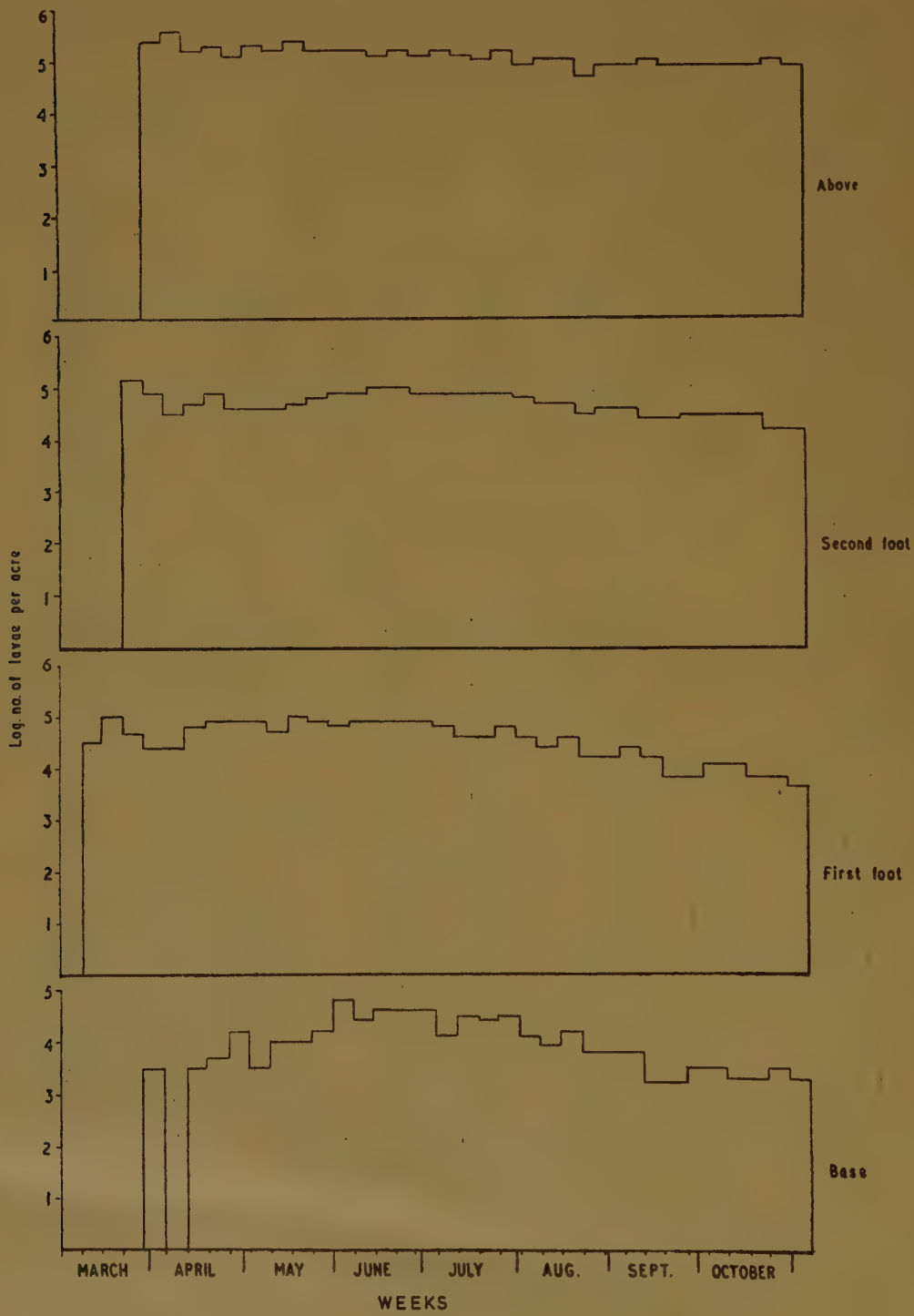
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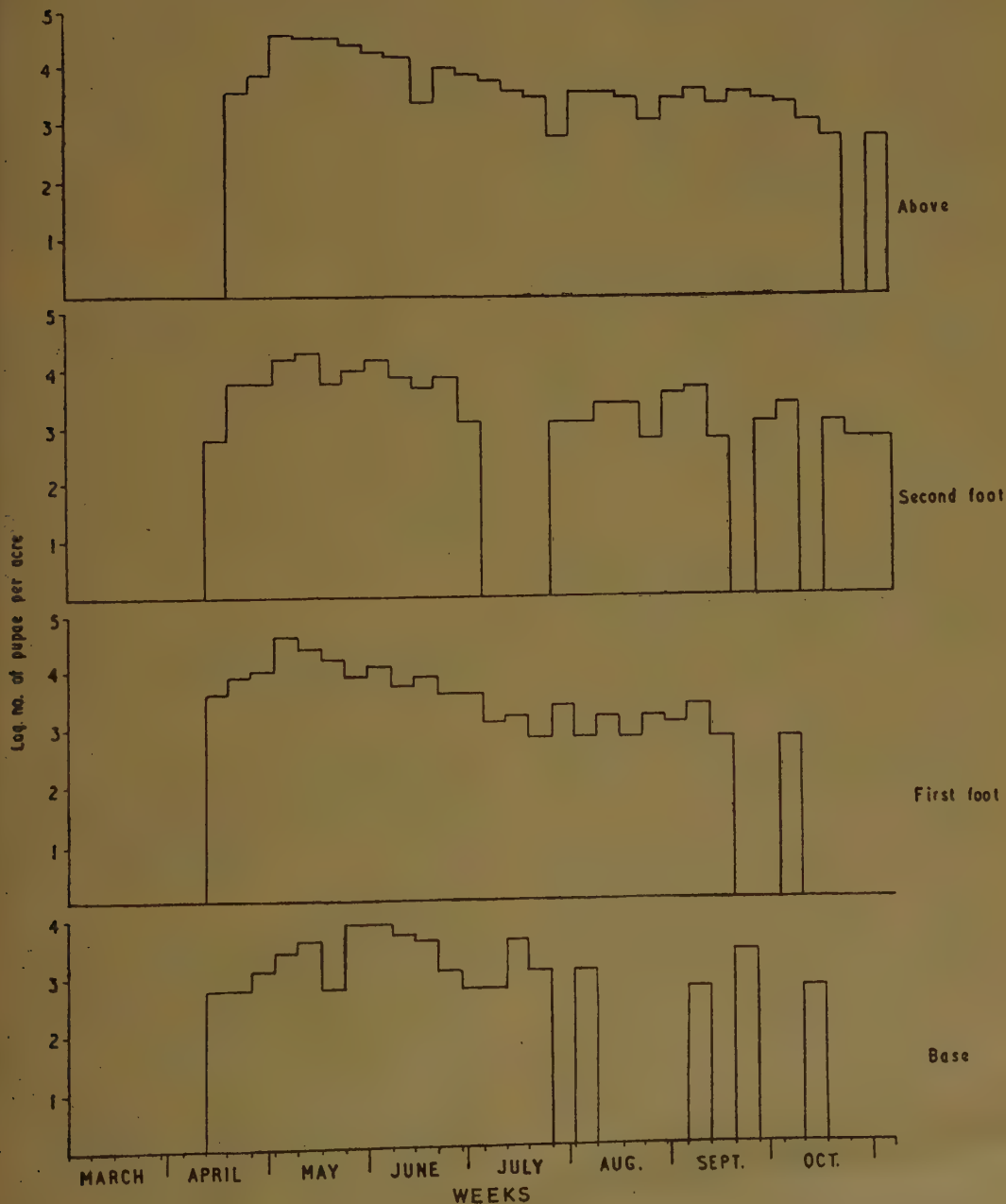












REVIEWS

PLANNED MANAGEMENT OF FORESTS, by N. V. Brasnett, published by George Allen and Unwin, Ltd., London, 1953, pp. 238, price 20/-.

This book is well worth detailed study in East Africa, for not only is it of benefit to Forest Officers, but also to the East African Governments, both central and local, and the various committees, both official and unofficial, who are dealing with the control of forest areas.

The author spent many years of his service in Uganda, and since his retirement has been teaching forest management to young Forest Officers, many destined for the colonies. Hence he has a wealth of experience, and we should be grateful to see it in print. There are many books on forest management but most deal with old-established European methods. This is one of the first books on the subject with a bias towards comparatively undeveloped tropical forests.

As the author says in his preface, the book has been compiled to provide students of forestry with a simple outline of what the management of forests involves and of the ways in which Foresters, working in various conditions, have attempted to organize and control their operations. We, in East Africa, are only at the very beginning of attempts at forest management, and it therefore behoves us to study this book and take advantage of the experiences and mistakes of the past in other countries.

The book is divided into three parts. Part I is a general description of the growth and organization of forest crops, Part II briefly describes how to plan the management of forests, and Part III is largely historical, describing the development of forest management in Western Europe.

Part II is, of course, of particular interest to Forest Officers and forest students, but Part III is of interest to all, for we are in the position of Western Europe of many centuries ago, and their experience and mistakes are set out for us to benefit by. In this history, it is of interest to note that there is a written record of forest management for the Spanish chestnut areas of the wine-growing districts of Southern Gaul in Pliny's 17th Book (about A.D. 50) which deals with short-rotation coppice crops of three to five years. How like some of our present East African short-rotation

crops of wattle and gums for which we have no management plans yet, 1,900 years later! The first Forest Code was the *Ordonnance de Melun* of France in 1376. Appendix 1 on p. 223 is of interest in showing the relation between the normal growing stock and production during a rotation of 70 years in teak plantations. These data are tropical and come from Malabar in South-West India where the teak plantations were started about 1840. Here we are just beginning to start plantation schemes and working plans, and the moral is obvious.

The book is well and clearly printed and above all it is readable and quite unlike the usual dry text-book in this respect. It is a pity that it contains no bibliography, for this would be of great use to students.

In conclusion, we must congratulate the author on filling a very great need. Let us hope that the next few years will see the production of many more simple forestry text-books dealing with primitive, comparatively unorganized, tropical forests.

A.L.G.

VETERINARY THERAPEUTICS: AN INTRODUCTION, by Geo. F. Boddie, published by Oliver and Boyd, Edinburgh and London, 1952, price 15/-.

Professor Boddie's book aims at presenting the basic principles of veterinary therapeutics in a concise and systematic manner, and within these limits the result is highly successful. The arrangement of the subject-matter is to be commended as is the author's usual direct and lucid literary style.

Apparently intended primarily for the use of veterinary students, this book is open to one serious criticism, namely that of over-simplification. One may sympathize with Professor Boddie's attempt to reduce the subject to its barest essentials (and this, it must be conceded, is the avowed intention of the author). Yet the final result is probably too technical for the layman without knowledge of chemistry or physiology, while "students, teachers and veterinary surgeons" will find much information missing which they might reasonably expect to find in a book of this nature. For example, one might mention the paucity of the descriptions of the vitamins and the chemotherapeutic drugs. Also, as this is essentially a practical book, a list of at least the more

important proprietary drugs (and many of these are extensively used in practice) together with their chemical and official names would be a welcome addition to this book.

Nevertheless this is a welcome and timely addition to veterinary literature. One hopes that future editions, which will assuredly be called for, will deal with an enlarged subject-matter as adequately as the edition now under review.

J.E.H.

FLORA OF EAST TROPICAL AFRICA.—*Onagraceae and Trapaceae*, by J. P. M. Brennan, Crown Agents for the Colonies, London, 1953, 24 and 4 pages, 2s., and 8d., respectively.

Parts of this much-needed work continue to arrive slowly; some think much too slowly. This slowness in appearance is, however, largely due to the thorough treatment each family is receiving, and this flora promises to be far more accurate than its West African counterpart. The two parts just received are from the pen of one of the most competent and meticulous botanists who have chosen African plants for their special study.

The two families dealt with are not tropical in content and both have representatives which occur or did occur in tertiary times in Britain.

Trapa natans, the sole species recognized in the family is a very widely dispersed plant at the present day and its spiny fruits are well-known objects in many fossil deposits. In East Africa it occurs in Lake Victoria, Lake Tanganyika and the Nile.

The larger part deals with the Onagraceae, a family well known to everyone since it contains *Chamaenerion angustifolium* (L.) Scop., the Rosebay willowherb and the large genus *Fuchsia*. The genus *Epilobium* has been rather troublesome to deal with in the past but Mr. Brennan has reduced the number of species to four, one of which he has restrained (commendably) to name until better material is available. The diagnostic illustrations by Mrs. Milne-Redhead render the naming of *Epilobium* species a very easy job.

Mr. Brennan's account of *Jussiaea*, a genus of rather insignificant plants, is masterly. This is largely due to the fact that his knowledge of world literature is very great and recent American work on the genus which has

been studied. He also makes a point of seeing all the types, which authors of such works as *The Flora of Tropical Africa*, often omitted to do. Plants long known by a certain name have turned out to be something quite different when the requisite type, often an ancient specimen, is completely examined. *Ludwigia* has been amalgamated with *Jussiaea* which makes for a more natural unit. This genus of eight difficult species has in the past been an absolute bugbear to African botanists and they will welcome this lucid account. The analytical drawings due to Miss Webster, Miss Thompson and Miss Stones are most helpful, and one suspects that the author carefully supervised the points he needed stressed.

A brief account of an introduced *Fuchsia* ends the part. It is fortunate that many future parts are to appear from the pen of Mr. Brennan since the part under review is the most lucid and competently written one yet to appear.

B.V.

STATISTICAL TABLES FOR BIOLOGICAL, AGRICULTURAL AND MEDICAL RESEARCH, by Sir Ronald A. Fisher and Frank Yates, Fourth Edition, revised and enlarged, published by Oliver and Boyd, London, 1953, price 21/-.

This book should need no introduction, but I have been surprised to find at least one research station without a copy of the earlier editions. It is an essential part of equipment for all research stations in East Africa, and should be available to all Agricultural Officers, however small their actual experimental programme.

The first edition was published in 1938, and several important tables were added to the 2nd and 3rd editions. The new edition gives tables of random arrangements of 10 and 20 treatments. This, of course, simplifies the work of the Agricultural Officer in the field, but arrangements can easily be obtained from the tables of random numbers contained in earlier editions.

A further table included in the new edition gives the values of the integral of the normal distribution. These values can, of course, be determined from either Table I or Table IX, given in earlier editions, but the new table gives information in a form more useful for certain purposes.

Two other tables included in the new edition are not of such general use; one is limited to the specialized field of genetics, and the other is used to test the significance of periodic components in a series.

P.R.

THE AFRICAN VETERINARY HANDBOOK, by P. Z. Mackenzie and R. M. Simpson, published by Sir Isaac Pitman & Sons, Ltd., Nairobi, 260 pages, price 15/-.

The book "sets out to describe for the layman, the diseases which affect animals in Africa". The authors have sufficient field and laboratory experience in the Sudan and Kenya to deserve the term experts and they have certainly presented in this attractive book a wealth of information suitably indexed and clarified with a most useful glossary.

The intelligent laymen who is willing to give time to its careful study will find much assistance in giving him a first indication of disease in his stock and in understanding the necessarily brief reports issued upon material submitted for veterinary diagnosis.

The desire to keep the book to a reasonable size results perhaps in cutting out a number of points which the farmer would have liked; thus in some cases careful dosage recommendations are given, e.g., with trypanocidal drugs, yet others are excluded, e.g., mercurochrome for anaplasmosis.

It is not the purpose of this note to review critically and in detail but a few points deserve criticism at this period; e.g., it is doubtful whether as stated, "most of the wild game animals such as buffalo and buck, living in the tsetse-infested country of Central Africa, possess a permanent infection of trypanosomes which cause them no harm"; or that in practice redwater "is characterized by the appearance of red blood pigment in the urine"; while success will probably not attend the attempt "to keep cattle in tsetse fly country with continuous prophylaxis with antrycide pro-salt given at four monthly intervals". On small practical points it should have been stressed that linseed oil for dosing animals should be raw linseed oil. No formula for tick grease, advised for hand-dressing, is given, nor any treatment of proud flesh in equine wounds, which are not infrequently inquired upon by the farmer.

These and a few other points, which are not of sufficient importance to be given here, are only to be regarded as suggested improvements

in any further edition and not as detracting in any way from the usefulness of this book as a veterinary handbook. The authors are indeed to be congratulated for the industry and care with which they have collected into one volume, for the first time in East Africa, so much valuable information in their subjects.

J.W.M.

MANUAL OF INFERTILITY AND ARTIFICIAL INSEMINATION IN CATTLE, by P. G. Millar and N. P. Ras, Bailliere, Tindall & Cox, price 25/-.

For many years there has been a great need for a practical book on reproductive physiology and infertility in cattle. This need is now well met by this admirable production by Millar and Ras, which should be of considerable value to veterinary surgeons, and indeed, as it is written in as simple and non-technical a manner as possible, to the farmer who wishes to take an intelligent interest in the problems of infertility in cattle and in the practice of artificial insemination.

The book deals with the reproductive anatomy and physiology of the cow and bull, pregnancy diagnosis and the semen of the bull. Infertility is presented in relation to genetics and developmental factors, the principal infective factors, female, male and herd fertility. A brief chapter on various environmental factors gives a rather unsatisfactory picture of the influence of management nutrition and acclimatization. The account of coital epididymitis and cervico-vaginitis adds to the topical value of the book for this is one of the most important causes of infertility in Kenya, Rhodesia and South Africa.

In this book, which is regarded as providing the essential practical information on infertility and artificial insemination of cattle, no attempt has purposely been made to provide any references to the literature on the subject, but even selected references would have been of help to those who require further and more detailed information on different aspects of these complex problems. Nevertheless the book can be confidently recommended to everyone concerned with the problems of reproduction in cattle in Kenya.

J.A.

THE INJURIOUS INSECTS OF THE BRITISH COMMONWEALTH (EXCEPT THE BRITISH ISLES, INDIA AND PAKISTAN), by J. W. Evans, M.A., SC.D., D.SC., Commonwealth Institute of Entomology, London, 1952, price Sh. 30.

This volume covers an immense field and it is not surprising that Dr. Evans has encountered difficulties of treatment and presentation. The information has been largely drawn from the first 38 volumes of the *Review of Applied Entomology* though a certain number of comprehensive original publications have also been drawn upon. The purpose of the book is to provide a source of reference and of concise information on most of the injurious insects of the British Commonwealth, with the exception of the British Isles, India and Pakistan. Brief descriptive notes are given in Part 1 of conditions in the territories covered, together with some concise information on insects of medical and veterinary importance, this latter material being included for the benefit of workers in other fields of entomology. Part 2 gives a useful quick reference to crop and insect pest associations, while Part 3 provides notes on pest species affecting agriculture, horticulture and forestry under a systematic arrangement. A brief but interesting and informative chapter on weed control by insects comprises Part 4. In the final chapter, Part 5, the author gives some observations on such matters as plant quarantine, virus vectors, insect control and research needs.

It is evident that the original plan for this book was even wider in scope, but, very understandably, this plan had to be curtailed. The book has unfortunately suffered to some extent from this curtailment, but is nevertheless worth a place in every entomological library. Dr. Evans himself realizes its limitations and is to be congratulated on making this first effort—always a difficult task. He is anxious that Commonwealth entomologists should appreciate the need for the preparation of comprehensive regional handbooks on injurious insects and for more co-operation and interchange of information between entomologists working within the Commonwealth. These aims have my fullest support and I feel sure that Dr. Evans will be satisfied if his volume helps to lead the way towards the realization of these ideals.

There is no doubt that this book will prove to be a useful reference book for those engaged in teaching entomology in colleges and

universities and for the technical staff of commercial organizations with pest control interests in the Commonwealth countries. It will also be useful to Commonwealth entomologists as a reference book, though to a much more limited extent. The manner of its compilation reduces its value to the working entomologist. Dr. Evans assumes (and the assumption must be very nearly fully valid) that every entomologist will have access to the *Review of Applied Entomology*. This publication gives summaries of entomological papers describing work in all parts of the world. On taking up a new investigation, an entomologist can quite speedily read all the summarized references to his subject and, as his own research work proceeds, evaluate these and if necessary take steps to consult some of the original papers. The *Review* only sets out to summarize papers as published and it is inevitable that it must in the process record inaccuracies and unfounded statements as well as real and correct facts. This is, of course, no criticism of the *Review*, which is in every way an excellent and indeed indispensable publication to the research worker, but it should be apparent that the evaluation of references can only be undertaken by a worker with intimate knowledge of the problem. Failing treatment by such, all references must be covered in any summarized extract if one is not to run the risk of giving an unbalanced account of the problem. It has not been possible for Dr. Evans to do this and one cannot help feeling that this volume would have been more useful to Commonwealth entomologists had they themselves been asked to submit, or at least check, material for their respective localities. It is because of this that the average entomologist will usually prefer to consult the *Review* itself even on minor matters.

In the reviewer's own field of work it is odd to find no mention of the important pest of coffee flower buds, *Lygus coffea* China; while the account of the Common Coffee Mealy Bug (*Planococcus kenyae* Le Pelley) on page 96 contains many inaccuracies. The footnote on this page is a misquotation from the *Review* summary itself (R.A.E. (A) 36, 403).

The book is attractively printed on quality paper and very appropriately carries as frontispiece a portrait of Sir Guy Marshall, the doyen of Commonwealth entomologists.

A.R.M.

YEAR BOOK OF AGRICULTURAL CO-OPERATION, 1953, edited by the Horace Plunkett Foundation and published by Basil Blackwell, Oxford, 1953, price Sh. 21.

This annual publication is the same size as the 1952 edition, which was reviewed in this JOURNAL, Vol. 18, p. 91, but the 1953 edition contains reviews of agricultural co-operation in many countries which were not included in the previous year. Reports on U.S.S.R., East Germany, Czechoslovakia, and Austria are of particular interest in relation to the Soviet political system, while articles on Finland, Denmark, Spain, Portugal, Brazil, Colombia, Belgian Congo, Trinidad, Eire and Ulster considerably widen the scope of the book.

It has long been apparent that primary agricultural producers, particularly those in the tropics, cannot afford to sell their products individually, and the steady increase in the number and size of co-operative societies is doing much to offset world fluctuations in market prices. The greater bargaining power which is given to the producer by co-operative marketing may tend to keep prices up, but the economic law of supply and demand still has final control of market prices. The overall trend appears to be towards economic stability in farming which encourages agricultural progress in general and soil improvement in particular. Thus the reviews contained in this book are of importance to those who plan the future of a country, since progress and economic trends in other countries will give them a wider view of their own economic problems.

D.W.D.

THE JOURNAL OF THE INDIAN SOCIETY OF SOIL SCIENCE, Vol. I, No. 1, June, 1953. Annual subscription Rs. 6 (inland), Rs. 8 (foreign), payable in Indian currency to the Indian Society of Soil Science, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 12.

This new Journal, which is to be issued bi-annually in June and December, will be of interest to field experimentalists and soil scientists in tropical and sub-tropical agriculture. The titles of the papers in the first number are: "The need for delineating the basic soil and climatic regions of importance to the plant industry": "Soil survey and fertilizer research in Uttar Pradesh": "Measurement of copper ion activity": "Soil fertility and

microbial activity": "Distribution of manganese in profiles of Indian soils": "Effect of different doses of superphosphate on the fixation of atmospheric nitrogen through pea": "Effect of some indigenous phosphates on the fixation of atmospheric nitrogen through pea": "Non-symbiotic nitrogen fixation by *Azotobacter* I. Effect of phosphorus on nitrogen fixation": and "Studies on the building up of soil fertility by the phosphatic fertilization of legumes. Influence of growing berseem on the nitrogen content of the soil".

The Indian Society of Soil Science is to be congratulated on producing a journal which should be of world-wide interest, and its present high standard augurs well for its future.

D.W.D.

PRODUCTION OF FIELD CROPS, by T. K. Wolfe and M. S. Kipps. McGraw-Hill Publishing Co., Ltd., Farringdon Street, London, E.C.4. Fourth edition, 1953, price Sh. 49.

Previous editions of this book were published in 1924, 1936 and 1948, and in the fourth edition the authors have again brought their material up to date. Their aim remains the same as that expressed in the preface to the first edition "to prepare a text with a wide field of usefulness rather than one limited to certain areas". Nevertheless, the fact that the book was written in the Southern States of America makes it of particular interest to farmers and agricultural officers in East Africa, since the crops studied are those which are most widely planted in this geographical area. The first section deals with agricultural practice in general—selection of seed, planting, and harvesting, with chapters on fertilizers and manures, grassland farming and pasture management, haymaking, silage, weeds and crop rotation. In the second section the practical aspects of cereal crop production are discussed, including maize, wheat, oats, barley, rye and rice. Section III deals with legumes for seed, including groundnuts, soya beans, cow peas, field peas and field beans. Forage crops are discussed in Section IV, which includes chapters on pasture and hay grasses, legumes, alfalfa, sorghums, millets and sunflowers. The root crops dealt with in Section V are sweet potatoes, carrots, mangels, and turnips, while Section VI consists of a chapter on cotton, flax and hemp. Section VII is on potatoes, Section VIII on sugar beets and sugar-cane, while the final chapter discusses the practical aspects of tobacco culture and curing.

In order to cover this wide range of crops in a book of 495 pages, the authors have necessarily selected and condensed their material, but emphasis on the usefulness of the book is retained. Much of the practice and technique may not be suitable for East Africa in its present stage of agricultural development, and it would be unwise to follow the practical advice blindly, but this is a valuable reference book with a comprehensive index which makes it easy to look up a particular point or subject.

D.W.D.

FIELD EXPERIMENTATION WITH FRUIT TREES AND OTHER PERENNIAL CROPS, by S. C. Pearce. Technical Communication No. 23 of the Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, England, 1953, pp. 131, price Sh. 10.

In field experiments with annual crops, the yields of several hundreds of plants are usually measured and used in the statistical analysis, whereas with fruit trees and most other perennial plants the population recorded is relatively small. In addition, perennial crops are more liable to be affected by pests and diseases, the results of which may persist for several years in the course of an experiment. With perennial crops, therefore, the differences between individual trees or plants becomes a factor of major importance because of the small numbers involved, whereas variation in production between annual crops is largely eliminated. The techniques that are used for overcoming soil heterogeneity with annual crops are therefore of limited value when applied to perennial crops.

In this book it is emphasized that the statistical design of a field trial should be such that the analysis would not be too complicated even when single trees or even whole plots be lost to the experiment. Although the designs are basically the same as for annual crops, it is suggested that every effort should be made to keep them simple in order to permit a fairly straightforward statistical analysis even where accidents have occurred. In presenting the designs the author has included provision for change of treatment, and accidental losses, and because of this the designs may appear to be rather confusing to those who are not experienced in statistical technique. It would probably have been better to give the basic designs first, without complication, and then to deal with the numerous modifications

which may be necessary. Some confusion may also arise from the notation used in the book; J, for example, is used to denote number of blocks, whereas this letter is usually reserved for part of the interaction between two factors at three levels, and F is used to denote a variance ratio throughout the book, except, at one point, it suddenly becomes number of degrees of freedom.

There are three appendices which give the statistical analysis, step by step, of certain selected experiments, and these methods can be applied in general to a wide variety of designs. A fourth appendix describes the analysis of covariance, which, for one independent variate, gives the procedure in detail, but for two independent variates the description is rather condensed, and consequently not as simple as it could have been. An extremely useful bibliography is also included.

P.R.

SYMPOSIUM ON CHROMOSOME BREAKAGE, Supplement to *Heredity*, Vol. 6, published by Oliver & Boyd, London and Edinburgh, 1953, price Sh. 45, or \$7.50.

This book, which contains 315 pages, gives a record of the proceedings of a symposium on chromosome breakage which was held at the John Innes Horticultural Institution, 9th to 11th June, 1952. In the Introduction, Professor C. D. Darlington, F.R.S., reviews the problem of chromosome breakage, and the 23 papers which follow are divided into four parts: radiation breakage; chemical breakage; secondary and spontaneous breakage; general.

In this symposium the most up-to-date experimental evidence is presented concerning the stage in cell development most affected by radiation and chemical agents, and the constitution of the chromosomes predisposing them to breakage and reunion. It also includes a comparison of the effects of radiation and chemical agents on chromosomes in somatic tissue and at the reproductive phase in plants, insects and animals, and a review of the biochemistry of chromosomes.

The biological importance of these studies is best illustrated by abstracts from Professor Darlington's introduction. Chromosome breakage can arise spontaneously, by chemical treatment and by ionising radiation of which atomic radiation is in some danger of becoming the most important. It is also the most effective

experimental agent of the death of cells and is therefore the chief means of cancer treatment. Jointly with gene mutation it is the agent of all genetic and evolutionary change. Chromosome breakage is an instrument for the dissection of chromosomes, a very useful tool for reaching an understanding of the working of the cell nuclei as a whole.

Finally Professor Darlington states, "Thus the conclusions reached both on the chemical and the morphological side of the Symposium reveal, not just the application of chemistry

to a biological study, not biochemistry as it has been understood, but actually the birth of a new kind of chemistry in which the sizes of the molecules concerned have brought some of their reactions within the range of the microscope. The dimensions and directions and speed of movement are no longer a matter of remote conjecture. They can be directly inferred. And they are taking place in the very centre of organization in the life of the cell".

L.R.D.

